SPECIFICATIONS

FOR

RW 9/27 RUNWAY STATUS LIGHTS – DESIGN

AT

MEMPHIS INTERNATIONAL AIRPORT

MEMPHIS, TENNESSEE

MSCAA PROJECT NO.: 16-1408-01

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RW 9/27 RUNWAY STATUS LIGHTS – DESIGN

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Item C-102 Temporary Air and Water Pollution, Soil Erosion, and Siltation Control

DESCRIPTION

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

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

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

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

MATERIALS

102-2.1 Sodding. Grass that will not compete with the grasses sown later for permanent cover per Item T-904 shall be a quick-growing species (such as ryegrass, Italian ryegrass, or cereal grasses) suitable to the area providing a temporary cover. Selected grass species shall not create a wildlife attractant.

102-2.2 Fertilizer. Fertilizer shall be a standard commercial grade and shall conform to all federal and state regulations and to the standards of the Association of Official Agricultural Chemists.

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

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

102-2.5 Other. All other materials shall meet commercial grade standards and shall be approved by the RPR before being incorporated into the project.

CONSTRUCTION REQUIREMENTS

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

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

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

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

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

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

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

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

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

102-3.4 Installation, maintenance and removal of silt fence. Silt fences shall extend a minimum of 3 feet above the ground surface. Posts shall be set no more than 6 feet on center. Filter fabric shall be cut from a continuous roll to the length required minimizing joints where possible. When joints are necessary, the fabric shall be spliced at a support post with a minimum 12-inch overlap and securely sealed. A trench shall be excavated approximately 6 inches deep by 6 inches wide on the upslope side of the silt fence. The

trench shall be backfilled and the soil compacted over the silt fence fabric. The Contractor shall remove and dispose of silt that accumulates during construction and prior to establishment of permanent erosion control. The fence shall be maintained in good working condition until permanent erosion control is established. Silt fence shall be removed upon approval of the RPR.

METHOD OF MEASUREMENT

102-4.1 Temporary erosion and pollution control work required will be performed as scheduled or directed by the RPR.

Installation and removal of silt fence will be measured by the linear foot, completed and accepted.

Catch basin sediment traps shall be measured per each item, completed and accepted.

Installation and removal of filter socks will be measured by the linear foot, completed and accepted.

102-4.2 Control work performed for protection of construction areas outside the construction limits, such as borrow and waste areas, haul roads, equipment and material storage sites, and temporary plant sites, will not be measured and paid for directly but shall be considered as a subsidiary obligation of the Contractor.

BASIS OF PAYMENT

102-5.1 Accepted quantities of temporary water pollution, soil erosion, and siltation control work ordered by the RPR and measured as provided in paragraph 102-4.1 will be paid for under:

Item C-102-5.1 Installation and removal of silt fence – per linear foot

Item C-102-5.2 Catch basin sediment trap – per each

Item C-102-5.3 Filter sock – per linear foot

Where other directed work falls within the specifications for a work item that has a contract price, the units of work shall be measured and paid for at the contract unit price bid for the various items.

Temporary control features not covered by contract items that are ordered by the RPR will be paid for in accordance with Section 90, paragraph 90-05 *Payment for Extra Work*.

REFERENCES

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

Advisory Circulars (AC)

AC 150/5200-33 *Hazardous Wildlife Attractants on or Near Airports*

AC 150/5370-2 *Operational Safety on Airports During Construction*

ASTM International (ASTM)

ASTM D6461 *Standard Specification for Silt Fence Materials*

United States Department of Agriculture (USDA)

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

END OF ITEM C-102

Item C-105 Mobilization

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

105-2 Mobilization limit. Mobilization shall be limited to 5 percent of the total project cost.

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

105-4 Engineer/RPR field office. An Engineer/RPR field office is not required.

METHOD OF MEASUREMENT

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

- **a.** With first pay request, 34%.
- **b.** With second pay request, an additional 33%.
- **c.** With third pay request, the final 33%.

BASIS OF PAYMENT

105-6 Payment will be made under:

Item C-105-6.1 Mobilization – per lump sum

REFERENCES

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

Office of Federal Contract Compliance Programs (OFCCP)

Executive Order 11246, as amended

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

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

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

END OF ITEM C-105

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Item P-151 Clearing and Grubbing

DESCRIPTION

151-1.1 This item shall consist of clearing and grubbing, including the disposal of materials, for all areas within the limits designated on the plans or as required by the Resident Project Representative (RPR).

a. Clearing and grubbing shall consist of clearing the surface of the ground of the designated areas of all trees, stumps, down timber, logs, snags, brush, undergrowth, hedges, heavy growth of grass or weeds, fences, structures, debris, and rubbish of any nature, natural obstructions or such material which in the opinion of the RPR is unsuitable for the foundation of strips, pavements, or other required structures, including the grubbing of stumps, roots, matted roots, foundations, and the disposal from the project of all spoil materials resulting from clearing and grubbing.

CONSTRUCTION METHODS

151-2.1 General. The areas denoted on the plans to be cleared and grubbed shall be staked on the ground by the Contractor as indicated on the plans.

The removal of existing structures and utilities required to permit orderly progress of work shall be accomplished by local agencies, unless otherwise shown on the plans. Whenever a telephone pole, pipeline, conduit, sewer, roadway, or other utility is encountered and must be removed or relocated, the Contractor shall advise the RPR who will notify the proper local authority or owner to secure prompt action.

151-2.1.1 Disposal. All materials removed by clearing and grubbing shall be disposed of outside the Airport's limits at the Contractor's responsibility, except when otherwise directed by the RPR. As far as practicable, waste concrete and masonry shall be placed on slopes of embankments or channels. When embankments are constructed of such material, this material shall be placed in accordance with requirements for formation of embankments. Any broken concrete or masonry that cannot be used in construction and all other materials not considered suitable for use elsewhere, shall be disposed of by the Contractor. In no case, shall any discarded materials be left in windrows or piles adjacent to or within the airport limits. The manner and location of disposal of materials shall be subject to the approval of the RPR and shall not create an unsightly or objectionable view. When the Contractor is required to locate a disposal area outside the airport property limits, the Contractor shall obtain and file with the RPR permission in writing from the property owner for the use of private property for this purpose.

151-2.1.2 Blasting. Blasting shall not be allowed.

151-2.2 Clearing and grubbing. In areas designated to be cleared and grubbed, all stumps, roots, buried logs, brush, grass, and other unsatisfactory materials as indicated on the plans, shall be removed, except where embankments exceeding 3-1/2 feet in depth will be constructed outside of paved areas. For embankments constructed outside of paved areas, all unsatisfactory materials shall be removed, but sound trees, stumps, and brush can be cut off flush with the original ground and allowed to remain. Tap roots and other projections over 1-1/2 inches in diameter shall be grubbed out to a depth of at least 18 inches below the finished subgrade or slope elevation.

Any buildings and miscellaneous structures that are shown on the plans to be removed shall be demolished or removed, and all materials shall be disposed of by removal from the site. The cost of removal is incidental to this item. The remaining or existing foundations, wells, cesspools, and like structures shall be destroyed by breaking down the materials of which the foundations, wells, cesspools, etc., are built to a depth at least 2 feet below the existing surrounding ground. Any broken concrete,

blocks, or other objectionable material that cannot be used in backfill shall be removed and disposed of at the Contractor's expense. The holes or openings shall be backfilled with acceptable material and properly compacted.

All holes in embankment areas remaining after the grubbing operation shall have the sides of the holes flattened to facilitate filling with acceptable material and compacting as required in Item P-152. The same procedure shall be applied to all holes remaining after grubbing in areas where the depth of holes exceeds the depth of the proposed excavation.

Existing drainage patterns shall be restored after clearing and grubbing is performed and other site improvements are completed.

METHOD OF MEASUREMENT

151-3.1 The quantities of clearing and grubbing as shown by the limits on the plans shall be the number of square yards or fractions thereof of land specifically cleared and grubbed.

BASIS OF PAYMENT

151-4.1 Payment shall be made at the contract unit price per square yard for clearing and grubbing. 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-151-4.1	Clearing and grubbing - per square yard

END OF ITEM P-151

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 (Earthwork). 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. Undercut excavation. This item shall include the excavation of unstable subgrade material as determined by the RPR. It shall be the Contractor's responsibility to perform proof-rolling and/or comparative efforts on the existing subgrade prior to authorization for undercutting. Materials used to replace "undercut" areas shall be obtained from the grading operations, from offsite borrow or shall be granular backfill as further defined herein.

c. 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 Contractor furnished pits off airport property. No material shall be excavated or brought on airport property without written permission from the RPR. Borrow material from non-approved pits will not be eligible for payment. Borrow excavation shall be further classified as follows:

(1) "Select borrow excavation" shall be classified as "ML" or "CL" soil in accordance with ASTM D-2487 (Unified Soils Classifications System) and shall have the properties given in the following table. If required the Contractor shall blend materials from the Contractor furnished pits to achieve these properties.

Soil Type	Liquid Limit[1]	Plasticity Index[1]	CBR[2]
ML	No Limit	No Limit	Min 6
CL	Max 45	10 to 24	Min 6

1. When tested in accordance with ASTM D-4318.
2. When remolded to the density which will be obtained during construction, soaked and tested in accordance with ASTM D-1883.

(2) "Unclassified borrow excavation" shall be any soil not classified as "unsuitable" per Section 152-1.2(c) and which can be readily placed and compacted in embankments.

d. Pavement excavation. This item shall include the full depth removal and disposal of existing bituminous or Portland Cement Concrete (PCC) pavement, abandoned bituminous or PCC pavement or existing bituminous or PCC shoulder pavement to proper subgrade elevation. Existing base and/or subbase may be stabilized or un-stabilized. Excavation shall be made to such depths as required to allow placement of new pavement section. Dispose of all excavated material off airport property unless otherwise directed by the Engineer.

152-1.3 Unsuitable excavation. Unsuitable material shall be disposed in designated waste areas as shown on the plans. This item shall include the excavation of: any materials containing vegetable or organic matter, such as muck, peat, organic silt, sod, or garbage; materials containing rubbish, trash or debris; or materials containing waste material such as bulky waste, commercial solid waste, construction and demolition waste, domestic waste, farming waste, and industrial waste. Petroleum impacted soil and hazardous waste shall not be considered to be unsuitable material. This item does not include clearing or clearing and grubbing waste as defined in P-151. Unsuitable material shall be disposed of off airport property at Contractor's expense.

The following paragraphs further define some of the above listed wastes:

Bulky Wastes: Large items of solid waste such as white goods, furniture, autos or large auto parts, trees, branches, stumps, and other oversize wastes whose large size precludes or complicates their handling by normal collection, processing or disposal methods.

Commercial Solid Wastes: All types of solid waste generated by stores, offices, restaurants, warehouses, and other manufacturing activities, excluding domestic and industrial waste.

Construction and Demolition Wastes: Wastes other than special wastes, resulting from construction, remodeling, repair and demolition of structures and from road building. Such wastes include but are not limited to bricks, concrete and other masonry materials, rock and lumber, road spoils, rebar, asphalt, and paving material. These types of wastes are not associated with, and shall not be paid for as, demolition of the airfield as required for this project, unless directed otherwise by the engineer.

Domestic Wastes: Any solid waste (including garbage and trash derived from households [including single and multiple residences], hotel and motels, bunkhouses, ranger stations, crew quarters, campgrounds, picnic grounds, and day-use recreation areas).

Farming Wastes: The wastes (except dead animals) from the customary and generally accepted activities, practices and procedures that farmers adopt, use, or engage in during the production and harvesting of agricultural crops which include agronomic, horticultural, and silvicultural crops. However, the term does not include special wastes such as waste oils or other lubricants, unused fertilizers, or pesticide containers or residues.

Hazardous Wastes: Means hazardous waste as defined in RCRA.

Industrial Wastes: Solid wastes produced in, or generated by, industrial or manufacturing processes. The term does not include commercial, domestic, mining, hazardous waste regulated under subtitled C or RCRA, or oil and gas waste.

152-1.4 Granular stone backfill. Granular backfill stone shall be CR-610 crushed stone.

CONSTRUCTION METHODS

152-2.1 General. Stripping will be required within the RWSL Shelter site prior to foundation and aggregate pad placement. The minimum depth of stripping shall be four (4) inches and the maximum depth shall be to the limits of the root zone.

The suitability of material to be placed in embankments shall be subject to approval by the RPR. All unsuitable material shall be disposed of in waste areas as shown on the plans. All waste areas shall be

graded to allow positive drainage of the area and adjacent areas. The surface elevation of waste areas shall be specified on the plans or approved by the RPR.

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

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

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

a. Blasting. Blasting shall not be allowed.

152-2.2 Excavation. No excavation shall be started until the work has been staked out by the Contractor on a maximum 50' x 50' survey grid for both horizontal and vertical grade control and the RPR has obtained from the Contractor, the survey notes of the elevations and measurements of the ground surface. The Contractor and RPR shall agree that the original ground lines shown on the original topographic mapping are accurate, or agree to any adjustments made to the original ground lines. All suitable excavated material shall be used in the formation of embankment, subgrade, or for other purposes shown on the plans. All unsuitable material shall be disposed of off airport property. Fine grading in preparation for paving shall not commence until the work has been staked out by the Contractor on a minimum 25' x 25' grid.

In pavement areas of any type to be removed and replaced, the existing pavement shall be sawed full-depth along the limits of construction. Existing free pavement edges shall be "nicked" as required to provide a straight vertical face. Pavement to be removed shall be carefully excavated to prevent damage to existing pavement to remain. The Contractor shall replace at this expense any pavement damaged outside the limits of demolition shown. The Contractor shall use a hoe-ram or other approved equipment for pavement demolition. The use of the crane and "head-ache" ball method of demolition is prohibited.

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 RPR. All suitable excavated material shall be used in the formation of embankment, subgrade, or other purposes as shown on the plans. All unsuitable material shall be disposed of as shown on the plans.

The Contractor shall perform all bracing, sheathing, or shoring necessary to implement and protect all excavations as required for safety, conformance to governing laws, or to prevent damage to surrounding items or features. The cost of said bracing, sheathing, and shoring shall be included in the unit price bid for the item requiring excavation.

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. Positive, effective drainage must be maintained at all times.

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

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

b. Undercutting. Rock, shale, hardpan, loose rock, boulders, or other material unsatisfactory for safety areas, subgrades, roads, shoulders, or any areas intended for turf shall be excavated to a minimum depth of 12 inches below the subgrade or to the depth specified by the RPR. 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 off airport property. 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. Undercutting will be paid as unclassified excavation.

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

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

152-2.3 Borrow excavation. There are no borrow sources within the boundaries of the airport property. The Contractor shall locate and obtain borrow sources, subject to the approval of the RPR. The Contractor shall notify the RPR at least 15 days prior to beginning the excavation so necessary measurements and tests can be made by the RPR. All borrow pits shall be opened to expose the various strata of acceptable material to allow obtaining a uniform product. Borrow areas shall be drained and left in a neat, presentable condition with all slopes dressed uniformly. Borrow areas shall not create a hazardous wildlife attractant.

152-2.4 Drainage excavation. Drainage excavation shall consist of excavating drainage ditches including intercepting, inlet, or outlet ditches; or other types as shown on the plans. The work shall be performed in sequence with the other construction. 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 RPR. 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 cut areas or areas where existing pavement has been removed. In those areas on which a subbase or base course is to be placed, the top 12 inches of subgrade shall be compacted to not less than 100 % of maximum density for non-cohesive soils, and 95% of maximum density for cohesive soils as determined by ASTM D698. As used in this specification, "non-cohesive" shall mean those soils having a plasticity index (PI) of less than 3 as determined by ASTM D4318.

152-2.6 Preparation of embankment area. 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 and shall then be compacted per paragraph 152-2.10.

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

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

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

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

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

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

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

Earthwork operations shall be suspended at any time when satisfactory results cannot be obtained due to rain, freezing, or other unsatisfactory weather conditions in the field. Frozen material shall not be placed in the embankment nor shall embankment be placed upon frozen material. Material shall not be placed on

surfaces that are muddy, frozen, or contain frost. The Contractor shall drag, blade, or slope the embankment to provide surface drainage at all times.

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

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

The Contractor will take samples of excavated materials which will be used in embankment for testing and develop a Moisture-Density Relations of Soils Report (Proctor) in accordance with D 1557. A new Proctor shall be developed for each soil type based on visual classification.

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

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

Rolling operations shall be continued until the embankment is compacted to not less than 95 percent of maximum density for non-cohesive soils, and 90 percent of maximum density for cohesive soils as determined by ASTM D1557. Under all areas to be paved, the embankments shall be compacted to a depth of 6 inches and to a density of not less than 100 percent of the maximum density as determined by ASTM D1557. As used in this specification, "non-cohesive" shall mean those soils having a plasticity index (PI) of less than 3 as determined by ASTM D4318.

On all areas outside of the pavement areas, no compaction will be required on the top 4 inches.

The in-place field density shall be determined in accordance with ASTM D1556. The Contractor’s laboratory shall perform all density tests in the RPR’s presence and provide the test results upon completion to the RPR for acceptance. If the specified density is not attained, the area represented by the test or as designated by the RPR shall be reworked and/or re-compacted and additional random tests made. This procedure shall be followed until the specified density is reached.

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

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

When rock, concrete pavement, asphalt pavement, and other embankment material are excavated at approximately the same time as the subgrade, the material shall be incorporated into the outer portion of the embankment and the subgrade material shall be incorporated under the future paved areas. Stones, fragmentary rock, and recycled pavement larger than 4 inches in their greatest dimensions will not be allowed in the top 12 inches of the subgrade. Rockfill shall be brought up in lifts as specified or as directed by the RPR and the finer material shall be used to fill the voids forming a dense, compact mass.

Rock, cement concrete pavement, asphalt pavement, and other embankment material shall not be disposed of except at places and in the manner designated on the plans or by the RPR.

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

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

152-2.9 Proof rolling. The purpose of proof rolling the subgrade is to identify any weak areas in the subgrade and not for compaction of the subgrade. Before start of embankment, the subgrade area shall be proof rolled with a 20 ton Tandem axle Dual Wheel Dump Truck loaded to the legal limit with tires inflated to 100 psi in the presence of the RPR. Apply a minimum of single coverage, or as specified by the RPR, under pavement areas. A coverage is defined as the application of one tire print over the designated area. Soft areas of subgrade that deflect more than 1 inch or show permanent deformation greater than 1 inch shall be removed and replaced with suitable material or reworked to conform to the moisture content and compaction requirements in accordance with these specifications. Removal and replacement of soft areas is incidental to this item.

152-2.10 Compaction requirements. Compaction requirements shall be in accordance with Paragraph 152-2.6.

The in-place field density shall be determined in accordance with ASTM D1556**.**

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

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

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

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

The Contractor shall maintain the completed course in satisfactory condition throughout placement of subsequent layers. No subbase, base, or surface course shall be placed on the subgrade until the subgrade has been accepted by the RPR.

152-2.12 Haul. All hauling will be considered a necessary and incidental part of the work. The Contractor shall include the cost in the contract unit price for the pay of items of work involved. No payment will be made separately or directly for hauling on any part of the work.

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

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

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

a. **Smoothness.** The finished surface shall not vary more than +/- ½ inch when tested with a 12-foot straightedge applied parallel with and at right angles to the centerline. The straightedge shall be moved continuously forward at half the length of the 12-foot straightedge for the full length of each line on a 50-foot grid.

b. **Grade.** The grade and crown shall be measured on a 50-foot grid and shall be within +/-0.05 feet of the specified grade.

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

152-2.14 Topsoil. 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 be located as shown on the plans and the approved CSPP, and shall not be placed on areas that subsequently will require any excavation or embankment fill. If, in the judgment of the RPR, 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 re-handling.

Upon completion of grading operations, stockpiled topsoil shall be handled and placed as shown on the plans and as required in Item T-905. Topsoil shall be paid for as provided in Item T-905. No direct payment will be made for topsoil under Item P-152.

METHOD OF MEASUREMENT

152-3.1 The quantity of unclassified excavation to be paid for shall be the number of cubic yards 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.

BASIS OF PAYMENT

152-4.1 Unclassified excavation payment shall be made at the contract unit price per cubic yard. 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

REFERENCES

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

American Association of State Highway and Transportation Officials (AASHTO)

AASHTO T-180	Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop

ASTM International (ASTM)

ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2700 kN-m/m^3))
ASTM D6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

Advisory Circulars (AC)

AC 150/5370-2	Operational Safety on Airports During Construction Software

Software

FAARFIELD – FAA Rigid and Flexible Iterative Elastic Layered Design

U.S. Department of Transportation

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

END OF ITEM P-152

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Item P-153 Controlled Low-Strength Material (CLSM)

DESCRIPTION

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

MATERIALS

153-2.1 Materials.

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

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

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

Sieve Size	Percent Passing by weight
3/4 inch	100
No. 200	0 - 12

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

MIX DESIGN

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

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

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

CONSTRUCTION METHODS

153-4.1 Placement.

a. Placement. CLSM may be placed by any reasonable means from the mixing unit into the space to be filled. Agitation is required during transportation and waiting time. Placement shall be performed so structures or pipes are not displaced from their final position and intrusion of CLSM into unwanted areas

is avoided. The material shall be brought up uniformly to the fill line shown on the plans or as directed by the RPR. Each placement of CLSM shall be as continuous an operation as possible. If CLSM is placed in more than one lift, the base lift shall be free of surface water and loose foreign material prior to placement of the next lift.

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

c. Limitations of placement. CLSM shall not be placed on frozen ground. Mixing and placing may begin when the air or ground temperature is at least 35°F and rising. Mixing and placement shall stop when the air temperature is 40°F and falling or when the anticipated air or ground temperature will be 35°F or less in the 24-hour period following proposed placement. At the time of placement, CLSM shall have a temperature of at least 40°F.

153-4.2 Curing and protection

a. Curing. The air in contact with the CLSM shall be maintained at temperatures above freezing for a minimum of 72 hours. If the CLSM is subjected to temperatures below 32°F, the material may be rejected by the RPR if damage to the material is observed.

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

153-4.3 Quality Assurance (QA) Acceptance. CLSM QA acceptance shall be based upon batch tickets provided by the Contractor to the RPR to confirm that the delivered material conforms to the mix design.

METHOD OF MEASUREMENT

153-5.1 Measurement. No separate measurement for payment shall be made for controlled low strength material (CLSM). CLSM shall be considered necessary and incidental to the work of this Contract.

BASIS OF PAYMENT

153-6.1 Payment. No payment will be made separately or directly for controlled low strength material (CLSM). CLSM shall be considered necessary and incidental to the work of this Contract.

REFERENCES

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

ASTM International (ASTM)

ASTM C33	Standard Specification for Concrete Aggregates
ASTM C150	Standard Specification for Portland Cement
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C595	Standard Specification for Blended Hydraulic Cements

ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D4832	Standard Test Method for Preparation and Testing of Controlled Low-Strength Material (CLSM) Test Cylinders
ASTM D6103	Flow Consistency of Controlled Low Strength Material (CLSM)

END OF ITEM P-153

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Item P-209 Crushed Aggregate Base Course

DESCRIPTION

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

MATERIALS

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

Crushed Aggregate Base Material Requirements

Material Test	Requirement	Standard
Coarse Aggregate		
Resistance to Degradation	Loss: 45% maximum	ASTM C131
Soundness of Aggregates by Use of Sodium Sulfate **or** Magnesium Sulfate	Loss after 5 cycles: 12% maximum using Sodium sulfate - or - 18% maximum using magnesium sulfate	ASTM C88
Percentage of Fractured Particles	Minimum 90% by weight of particles with at least two fractured faces and 98% with at least one fractured face[1]	ASTM D5821
Flat Particles, Elongated Particles, or Flat and Elongated Particles	10% maximum, by weight, of flat, elongated, or flat and elongated particles [2]	ASTM D4791
Fine Aggregate		
Liquid limit	Less than or equal to 25	ASTM D4318
Plasticity Index	Not more than five (5)	ASTM D4318

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

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

209-2.2 Gradation requirements. The gradation of the aggregate base material shall meet the requirements of the gradation given in the following table when tested per ASTM C117 and ASTM C136.

The gradation shall be well graded from coarse to fine and shall not vary from the lower limit on one sieve to the high limit on an adjacent sieve or vice versa.

Gradation of Aggregate Base

Sieve Size	Design Range Percentage by Weight passing	Contractor's Final Gradation	Job Control Grading Band Tolerances[1] (Percent)
2 inch	100		0
1-1/2 inch	95-100		±5
1 inch	70-95		±8
3/4 inch	55-85		±8
No. 4	30-60		±8
No. 40[2]	10-30		±5
No. 200[2]	0-10		±3

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

[2] The fraction of material passing the No 200 sieve shall not exceed two-thirds the fraction passing the No 40 sieve.

209-2.3 Sampling and Testing.

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

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

209-2.4 Separation Geotextile. Separation geotextile shall be Class 2, 0.02 sec-1 permittivity per ASTM D4491, Apparent opening size per ASTM D4751 with 0.60 mm maximum average roll value.

CONSTRUCTION METHODS

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

Control strips that do not meet specification requirements shall be reworked, re-compacted or removed and replaced at the Contractor's expense. Full operations shall not continue until the control strip has

been accepted by the RPR. The Contractor shall use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments made by the Contractor are approved by the RPR.

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

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

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

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

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

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

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

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

209-3.7 Maintenance. The base course shall be maintained in a condition that will meet all specification requirements. When material has been exposed to excessive rain, snow, or freeze-thaw conditions, prior to placement of additional material, the Contractor shall verify that materials still meet all specification requirements. Equipment may be routed over completed sections of base course, provided that no damage

results and the equipment is routed over the full width of the completed base course. Any damage resulting to the base course from routing equipment over the base course shall be repaired by the Contractor at the Contractor's expense.

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

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

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

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

a. Density. The RPR shall perform all density tests.

Each area shall be accepted for density when the field density is at least 100% of the maximum density of laboratory specimens compacted and tested per ASTM 1557. The in-place field density shall be determined per ASTM D1556 or ASTM D6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938. If the specified density is not attained, the area represented by the failed test must be reworked and/or recompacted and two additional random tests made. This procedure shall be followed until the specified density is reached. Maximum density refers to maximum dry density at optimum moisture content unless otherwise specified.

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

METHOD OF MEASUREMENT

209-4.1 The quantity of crushed aggregate base course will be determined by measurement of the number of tons of material actually constructed and accepted by the RPR as complying with the plans and specifications. Base materials shall not be included in any other excavation quantities.

BASIS OF PAYMENT

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

Payment will be made under:

Item P-209-5.1	Crushed Aggregate Base Course - per ton

REFERENCES

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

ASTM International (ASTM)

ASTM C29	Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C142	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2700 kN-m/m^3))
ASTM D2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity

ASTM D4643	Standard Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating
ASTM D4751	Standard Test Methods for Determining Apparent Opening Size of a Geotextile
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5821	Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D7928	Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

American Association of State Highway and Transportation Officials (AASHTO)

M288	Standard Specification for Geosynthetic Specification for Highway Applications

END OF ITEM P-209

Item P-605 Joint Sealants for Pavements

DESCRIPTION

605-1.1 This item shall consist of providing and installing a resilient and adhesive joint sealing material capable of effectively sealing joints in pavement; joints between different types of pavements; and cracks in existing pavement.

MATERIALS

605-2.1 Joint sealants. Joint sealant materials shall meet the requirements of the following:

1. Concrete Pavement Joints – A low modulus, cold applied, silicone sealant in conformance with ASTM D5893 - Standard Specifications for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.
2. Bituminous Shoulder-Concrete Pavement Interface Joint – A hot-poured, jet fuel resistant, sealant for concrete and asphalt in conformance with ASTM D6690 - Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

Each lot or batch of sealant shall be delivered to the jobsite in the manufacturer's original sealed container. Each container shall be marked with the manufacturer's name, batch or lot number, the safe heating temperature, and shall be accompanied by the manufacturer's certification stating that the sealant meets the requirements of this specification.

605-2.2 Backer rod. The material furnished shall be a compressible, non-shrinking, non-staining, non-absorbing material that is non-reactive with the joint sealant in accordance with ASTM D5249. The backer-rod material shall be 25% ± 5 % larger in diameter than the nominal width of the joint.

605-2.3 Bond breaking tapes. Provide a bond breaking tape or separating material that is a flexible, non-shrinkable, non-absorbing, non-staining, and non-reacting adhesive-backed tape. The material shall have a melting point at least 5°F 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 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 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, 14 days prior to use on the project.

a. Concrete saw. Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified.

b. Sandblasting equipment. The Contractor must demonstrate sandblasting equipment including the air compressor, hose, guide and nozzle size, under job conditions, before approval in accordance with paragraph 605-3.3. The Contractor shall demonstrate, in the presence of the Resident Project Representative (RPR), that the method cleans the joint and does not damage the joint.

c. Waterblasting equipment. The Contractor must demonstrate waterblasting equipment including the pumps, hose, guide and nozzle size, under job conditions, before approval in accordance with paragraph 605-3.3. The Contractor shall demonstrate, in the presence of the RPR, that the method cleans the joint and does not damage the joint.

d. Hand tools. Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces. Hand tools should be carefully evaluated for potential spalling effects prior to approval for use.

e. Hot-poured sealing equipment. The unit applicators used for heating and installing ASTM D6690 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. The applicator unit shall be designed so that the sealant will circulate through the delivery hose and return to the inner kettle when not in use.

f. Cold-applied, single-component sealing equipment. The equipment for installing ASTM D5893 single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

605-3.3 Preparation of joints. Pavement joints for application of material in this specification must be dry, clean of all scale, dirt, dust, curing compound, and other foreign matter. The Contractor shall demonstrate, in the presence of the RPR, that the method cleans the joint and does not damage the joint.

a. Sawing. All joints shall be sawed in accordance with specifications and plan details. Immediately after sawing the joint, the resulting slurry shall be completely removed from joint and adjacent area by flushing with a jet of water, and by use of other tools as necessary.

b. Sealing. Immediately before sealing, the joints shall be thoroughly cleaned of all remaining laitance, curing compound, filler, protrusions of hardened concrete, old sealant and other foreign material from the sides and upper edges of the joint space to be sealed. Cleaning shall be accomplished by sandblasting or waterblaster only if permitted by the RPR, as specified in paragraph 605-3.2. The newly exposed concrete joint faces and the pavement surface extending a minimum of 1/2 inch 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 from it. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water. The joint faces shall be surface dry when the seal is applied.

c. Backer Rod. When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a backer rod in accordance with paragraph 605-2.2

to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backer rod is placed at the specified depth and is not stretched or twisted during installation.

d. Bond-breaking tape. Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond-separating tape breaker in accordance with paragraph 605-2.3 to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.

605-3.4 Installation of sealants. Joints shall be inspected for proper width, depth, alignment, and preparation, and shall be approved by the RPR before sealing is allowed. Sealants shall be installed in accordance with the following requirements:

Immediately preceding, but not more than 50 feet ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 1/4 inch ±1/16 inch below the top of pavement surface; or bottom of groove for grooved pavement. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the RPR. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

605-3.5 Inspection. The Contractor shall inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified at no additional cost to the airport.

605-3.6 Clean-up. Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

METHOD OF MEASUREMENT

605-4.1 No measurement will be made for the direct payment of sealing of joints required in the construction of concrete pavements. The cost of furnishing and installing joint sealing material shall be considered as a subsidiary obligation in the completion of the construction.

BASIS OF PAYMENT

605-5.1 No direct payment will be made for sealing of joints. The cost of all required joint sealing will be included in the applicable paving items for which it is a component part. The contract unit price for paving shall be full compensation for furnishing all materials, for all preparation, delivering and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

REFERENCES

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

ASTM International (ASTM)

ASTM D789	Standard Test Method for Determination of Relative Viscosity of Polyamide (PA)
ASTM D5249	Standard Specification for Backer Material for Use with Cold- and Hot-Applied Joint Sealants in Portland-Cement Concrete and Asphalt Joints
ASTM D5893	Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements
ASTM D6690	Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt

Advisory Circulars (AC)

AC 150/5340-30	Design and Installation Details for Airport Visual Aids

END ITEM P-605

Item P-606 Adhesive Compounds, Two-Component for Sealing Wire and Lights in Pavement

DESCRIPTION

606-1.1 This specification covers two types of material; a liquid suitable for sealing electrical wire in saw cuts in pavement and for sealing light fixtures or bases in pavement, and a paste suitable for embedding light fixtures in the pavement. Both types of material are two-component filled formulas with the characteristics specified in paragraph 606-2.4. Materials supplied for use with asphalt and/or concrete pavements must be formulated so they are compatible with the asphalt and/or concrete.

MATERIALS

606-2.1 Curing. When pre-warmed to 77°F, mixed, and placed in accordance with manufacturer's directions, the materials shall cure at temperatures of 45°F or above without the application of external heat.

606-2.2 Storage. The adhesive components shall not be stored at temperatures over 86°F, unless otherwise specified by the manufacturer.

606-2.3 Caution. Installation and use shall be in accordance with the manufacturer's recommended procedures. Avoid prolonged or repeated contact with skin. In case of contact, wash with soap and flush with water. If taken internally, call doctor. Keep away from heat or flame. Avoid vapor. Use in well-ventilated areas. Keep in cool place. Keep away from children.

606-2.4 Characteristics. When mixed and cured in accordance with the manufacturer's directions, the materials shall have the following properties shown in Table 1.

Table 1. Property Requirements

Physical or Electrical Property	Minimum	Maximum	ASTM Method
Tensile			
Portland cement concrete	1,000 psi		D 638
Asphalt concrete	500 psi		
Elongation			
Portland cement concrete		See note [1]	D 638
Asphalt concrete	50%		D 638
Coef. of cub. exp. cu. cm/cu. cm/°C	0.00090	0.00120	D 1168
Coef. of lin. exp. cm/cm/°C	0.000030	0.000040	D 1168
Dielectric strength, short time test	350 volts/mil.		D 149
Arc resistance	125 sec		
Pull-off			
Adhesion to steel	1,000 psi		
Adhesion to Portland cement concrete	200 psi		
Adhesion to asphalt concrete	No test available.		
Adhesion to aluminum	250 psi		

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

SAMPLING, INSPECTION, AND TEST PROCEDURES

606-3.1 Tensile properties. Tests for tensile strength and elongation shall be conducted in accordance with ASTM D638.

606-3.2 Expansion. Tests for coefficients of linear and cubical expansion shall be conducted in accordance with, Method B, except that mercury shall be used instead of glycerine. The test specimen shall be mixed in the proportions specified by the manufacturer, and cured in a glass tub approximately 2 inch long by 3/8 inch 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 to 140°F.

606-3.3 Test for dielectric strength. Test for dielectric strength shall be conducted in accordance with ASTM D149 for sealing compounds to be furnished for sealing electrical wires in pavement.

606-3.4 Test for arc resistance. Test for arc resistance shall be conducted for sealing compounds to be furnished for sealing electrical wires in pavement.

606-3.5 Test for adhesion to steel. The ends of two smooth, clean, steel specimens of convenient size (1 inch by 1 inch by 6 inch) 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.

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 of water per bag of cement, a cement factor of 6, ±0.5, bags of cement per cubic yard of concrete, and a slump of 2-1/2 inch, ±1/2 inch. 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 by 2-inch by 3-inch test blocks can be cut from the specimen with a concrete saw having a diamond blade. The concrete shall be prepared and cured in accordance with ASTM C192.

Table 2. Aggregate for Bond Test Blocks

Type	Sieve Size	Percent Passing
Coarse Aggregate	3/4 inch	97 to 100
	1/2 inch	63 to 69
	3/8 inch	30 to 36
	No. 4	0 to 3
Fine Aggregate	No. 4	100
	No. 8	82 to 88
	No. 16	60 to 70
	No. 30	40 to 50
	No. 50	16 to 26
	No. 100	5 to 9

b. Bond test. Prior to use, oven-dry the test blocks to constant weight at a temperature of 220°F to 230°F, cool to room temperature, 73.4°F ±3°F, 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 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.

606-3.7 Compatibility with asphalt mix. Test for compatibility with asphalt in accordance with ASTM D5329.

606-3.8 Adhesive compounds - Contractor's responsibility. The Contractor shall furnish the vendor's certified test reports for each batch of material delivered to the project. The report shall certify that the material meets specification requirements and is suitable for use with concrete pavements. The report shall be provided to and accepted by the Resident Project Representative (RPR) before use of the material. In addition, the Contractor shall obtain a statement from the supplier or manufacturer that

guarantees the material for one year. The supplier or manufacturer shall furnish evidence that the material has performed satisfactorily on other projects.

606-3.9 Application. Adhesive shall be applied on a dry, clean surface, free of grease, dust, and other loose particles. The method of mixing and application shall be in strict accordance with the manufacturer's recommendations. When used with Item P-605, such as light can installation, Item P-605 shall not be applied until the Item P-606 has fully cured.

METHOD OF MEASUREMENT

606-4.1 The adhesive compound shall not be measured directly but shall be considered incidental to the work.

BASIS OF PAYMENT

606-5.1 No direct payment for the adhesive compound shall be made, as it will be considered incidental to the work.

REFERENCES

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

ASTM International (ASTM)

ASTM C192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM D149	Standard Test Method for Dielectric Breakdown Voltage and Dielectric Strength of Solid Electrical Insulating Materials at Commercial Power Frequencies
ASTM D638	Standard Test Method for Tensile Properties of Plastics
ASTM D5329	Standard Test Methods for Sealants and Fillers, Hot-applied, for Joints and Cracks in Asphaltic and Portland Cement Concrete Pavements

END OF ITEM P-606

Item P-610 Concrete for Miscellaneous Structures

DESCRIPTION

610-1.1 This item shall consist of concrete and reinforcement, as shown on the plans, prepared and constructed in accordance with these specifications. This specification shall be used for all concrete other than airfield pavement which are cast-in-place.

MATERIALS

610-2.1 General. Only approved materials, conforming to the requirements of these specifications, shall be used in the work. Materials may be subject to inspection and tests at any time during their preparation or use. The source of all materials shall be approved by the Resident Project Representative (RPR) before delivery or use in the work. Representative preliminary samples of the materials shall be submitted by the Contractor, when required, for examination and test. Materials shall be stored and handled to ensure preservation of their quality and fitness for use and shall be located to facilitate prompt inspection. All equipment for handling and transporting materials and concrete must be clean before any material or concrete is placed in them.

The use of pit-run aggregates shall not be permitted unless the pit-run aggregate has been screened and washed, and all fine and coarse aggregates stored separately and kept clean. The mixing of different aggregates from different sources in one storage stockpile or alternating batches of different aggregates shall not be permitted.

a. Reactivity. Fine aggregate and coarse aggregates to be used in all concrete shall have been tested separately within six months of the project in accordance with ASTM C1260. Test results shall be submitted to the RPR. The aggregate shall be considered innocuous if the expansion of test specimens, tested in accordance with ASTM C1260, does not exceed 0.08% at 14 days (16 days from casting). If the expansion either or both test specimen is greater than 0.08% at 14 days, but less than 0.20%, a minimum of 25% of Type F fly ash, or between 40% and 55% of slag cement shall be used in the concrete mix.

If the expansion is greater than 0.20%, the aggregates shall not be used, and test results for other aggregates must be submitted for evaluation; or aggregates that meet P-501 reactivity test requirements may be utilized.

610-2.2 Coarse aggregate. The coarse aggregate for concrete shall meet the requirements of ASTM C33 and the requirements of Table 4, Class Designation 5S; and the grading requirements shown below, as required for the project.

Coarse Aggregate Grading Requirements

Maximum Aggregate Size	ASTM C33, Table 3 Grading Requirements (Size No.)
1 1/2 inch	467 or 4 and 67
1 inch	57
¾ inch	67
½ inch	7

610-2.2.1 Coarse aggregate susceptibility to durability (D) cracking. Coarse aggregate may only be accepted from sources that have a 20-year service history for the same gradation to be supplied with no history of D-Cracking. Aggregates that do not have a 20-year record of service free from major repairs (less than 5% of slabs replaced) in similar conditions without D-cracking shall not be used unless the material currently being produced has a durability factor greater than or equal to 95 per ASTM C666. The Contractor shall submit a current certification and test results to verify the aggregate acceptability. Test results will only be accepted from a State Department of Transportation (DOT) materials laboratory or an accredited laboratory. Certification and test results which are not dated or which are over one (1) year old or which are for different gradations will not be accepted.

Crushed granite, calcite cemented sandstone, quartzite, basalt, diabase, rhyolite or trap rock are considered to meet the D-cracking test requirements but must meet all other quality tests specified below.

Coarse Aggregate Material Requirements

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

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

[2] Only required if slag is specified.

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

Limits for Deleterious Substances in Coarse Aggregate

Deleterious material	ASTM	Percentage by Mass
Clay Lumps and friable particles	ASTM C142	1.0
Material finer than No. 200 sieve (75µm)	ASTM C117	1.0[1]
Lightweight particles	ASTM C123 using a medium with a density of Sp. Gr. of 2.0	0.5
Chert[2] (less than 2.40 Sp Gr.)	ASTM C123 using a medium with a density of Sp. Gr. of 2.40)	1.0[3]

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

[2] Chert and aggregates with less than 2.4 specific gravity.

[3] The limit for chert may be limited to 0.1 percent by mass in areas not subject to severe freeze and thaw.

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

610-2.4 Cement. Cement shall conform to the requirements of ASTM C150 Type I/II or III.

610-2.5 Cementitious materials.

a. Fly ash. Fly ash shall meet the requirements of ASTM C618, with the exception of loss of ignition, where the maximum shall be less than 6%. Fly ash shall have a Calcium Oxide (CaO) content of less than 15% and a total available alkali content less than 3% per ASTM C311. Fly ash produced in furnace operations using liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The Contractor shall furnish the previous three most recent, consecutive ASTM C618 reports for each source of fly ash proposed in the concrete mix, and shall furnish each additional report as they become available during the project. The reports can be used for acceptance or the material may be tested independently by the RPR.

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

610-2.6 Water. Water used in mixing or curing shall be from potable water sources. Other sources shall be tested in accordance with ASTM C1602 prior to use.

610-2.7 Admixtures. The Contractor shall submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the RPR 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 RPR 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 RPR. Retarding shall meet the requirements of ASTM C494, Type A, B, or D and set-accelerating shall meet the requirements of ASTM C494, Type C. Calcium chloride and admixtures containing calcium chloride shall not be used.

610-2.8 Premolded joint material. Premolded joint material for expansion joints shall meet the requirements of ASTM D1751.

610-2.9 Joint filler. The filler for joints shall meet the requirements of Item P-605, unless otherwise specified.

610-2.10 Steel reinforcement. Reinforcing shall consist of welded steel wire fabric conforming to the requirements of ASTM A1064, ASTM A844 or bar mats conforming to the requirements of ASTM A184 or ASTM A704.

610-2.11 Materials for curing concrete. Curing materials shall conform to one of the following: 1) waterproof paper meeting the requirements of ASTM C171, 2) clear or white polyethylene sheeting meeting the requirements of ASTM C171, or 3) white-pigmented liquid membrane-forming compound, Type 2, Class B meeting the requirements of 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 RPR.

610-3.2 Concrete Mixture. The concrete shall develop a compressive strength of 4000 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 per cubic yard. The water cementitious ratio shall not exceed 0.45 by weight. The air content of the concrete shall be 5% +/- 1.2% as determined by ASTM C231 and shall have a slump of not more than 4 inches as determined by ASTM C143.

610-3.3 Mixing. Concrete may be mixed at the construction site, at a central point, or wholly or in part in truck mixers. The concrete shall be mixed and delivered in accordance with the requirements of ASTM C94 or ASTM C685.

The concrete shall be mixed only in quantities required for immediate use. Concrete shall not be mixed while the air temperature is below 40°F without the RPRs approval. If approval is granted for mixing under such conditions, aggregates or water, or both, shall be heated and the concrete shall be placed at a temperature not less than 50°F nor more than 100°F. The Contractor shall be held responsible for any defective work, resulting from freezing or injury in any manner during placing and curing, and shall replace such work at his expense.

Retempering of concrete by adding water or any other material is not permitted.

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

610-3.4 Forms. Concrete shall not be placed until all the forms and reinforcements have been inspected and approved by the RPR. Forms shall be of suitable material and shall be of the type, size, shape, quality, and strength to build the structure as shown on the plans. The forms shall be true to line and grade and shall be mortar-tight and sufficiently rigid to prevent displacement and sagging between supports. The surfaces of forms shall be smooth and free from irregularities, dents, sags, and holes. The Contractor shall be responsible for their adequacy.

The internal form ties shall be arranged so no metal will show in the concrete surface or discolor the surface when exposed to weathering when the forms are removed. All forms shall be wetted with water or with a non-staining mineral oil, which shall be applied immediately before the concrete is placed. Forms shall be constructed so they can be removed without injuring the concrete or concrete surface.

610-3.5 Placing reinforcement. All reinforcement shall be accurately placed, as shown on the plans, and shall be firmly held in position during concrete placement. Bars shall be fastened together at intersections. The reinforcement shall be supported by approved metal chairs. Shop drawings, lists, and bending details shall be supplied by the Contractor when required.

610-3.6 Embedded items. Before placing concrete, all embedded items shall be firmly and securely fastened in place as indicated. All embedded items shall be clean and free from coating, rust, scale, oil, or any foreign matter. The concrete shall be spaded and consolidated around and against embedded items. The embedding of wood shall not be allowed.

610-3.7 Concrete Consistency. The Contractor shall monitor the consistency of the concrete delivered to the project site; collect each batch ticket; check temperature; and perform slump tests on each truck at the project site in accordance with ASTM C143.

610-3.8 Placing concrete. All concrete shall be placed during daylight hours, unless otherwise approved. The concrete shall not be placed until the depth and condition of foundations, the adequacy of forms and falsework, and the placing of the steel reinforcing have been approved by the RPR. 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. Concrete shall be deposited as nearly as practical in its final position to avoid segregation due to rehandling or flowing. Do not subject concrete to procedures which cause segregation. Concrete shall be placed on clean, damp surfaces, free from running water, or on a properly consolidated soil foundation.

610-3.9 Vibration. Vibration shall follow the guidelines in American Concrete Institute (ACI) Committee 309R, Guide for Consolidation of Concrete.

610-3.10 Joints. Joints shall be constructed as indicated on the plans.

610-3.11 Finishing. All exposed concrete surfaces shall be true, smooth, and free from open or rough areas, depressions, or projections. All concrete horizontal plane surfaces shall be brought flush to the proper elevation with the finished top surface struck-off with a straightedge and floated.

610-3.12 Curing and protection. All concrete shall be properly cured in accordance with the recommendations in American Concrete Institute (ACI) 308R, Guide to External Curing of Concrete. The concrete shall be protected from damage until project acceptance.

610-3.13 Cold weather placing. When concrete is placed at temperatures below 40°F, follow the cold weather concreting recommendations found in ACI 306R, Cold Weather Concreting.

610-3.14 Hot weather placing. When concrete is placed in hot weather greater than 85ºF, follow the hot weather concreting recommendations found in ACI 305R, Hot Weather Concreting.

QUALITY ASSURANCE (QA)

610-4.1 Quality Assurance sampling and testing. Concrete for each day's placement will be accepted on the basis of the compressive strength specified in paragraph 610-3.2. The RPR will sample the concrete in accordance with ASTM C172; test the slump in accordance with ASTM C143; test air content in accordance with ASTM C231; make and cure compressive strength specimens in accordance with ASTM C31; and test in accordance with ASTM C39. The QA testing agency will meet the requirements of ASTM C1077.

The Contractor shall provide adequate facilities for the initial curing of cylinders.

610-4.2 Defective work. Any defective work that cannot be satisfactorily repaired as determined by the RPR, shall be removed and replaced at the Contractor's expense. Defective work includes, but is not limited to, uneven dimensions, honeycombing and other voids on the surface or edges of the concrete.

METHOD OF MEASUREMENT

610-5.1 Concrete shall be considered incidental and no separate measurement shall be made.

BASIS OF PAYMENT

610-6.1 Concrete shall be considered incidental and no separate payment shall be made.

REFERENCES

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

ASTM International (ASTM)

ASTM A184	Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A704	Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
ASTM A706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A884	Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement

ASTM A934	Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C150	Standard Specification for Portland Cement
ASTM C171	Standard Specification for Sheet Materials for Curing Concrete
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C311	Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete
ASTM C494	Standard Specification for Chemical Admixtures for Concrete
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
ASTM C685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM C1017	Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1157	Standard Performance Specification for Hydraulic Cement

ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1365	Standard Test Method for Determination of the Proportion of Phases in Portland Cement and Portland-Cement Clinker Using X-Ray Powder Diffraction Analysis
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Asphalt Types)
ASTM D1752	Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction

American Concrete Institute (ACI)

ACI 305R	Hot Weather Concreting
ACI 306R	Cold Weather Concreting
ACI 308R	Guide to External Curing of Concrete
ACI 309R	Guide for Consolidation of Concrete

END OF ITEM P-610

Item P-611 Quick Setting High Early Strength Structural Concrete

DESCRIPTION

611-1.1 This item shall consist of plain and reinforced quick setting high early strength structural cement concrete, prepared and constructed in accordance with these specifications, at the locations and of the form and dimensions shown on the plans.

a. Related work specified elsewhere. The provisions and intent of the Contract, including the General Conditions, Supplementary Conditions, and General Requirements apply to the Work as if specified in this section. Work related to this section is described in:

1. Portland Cement Concrete Pavement (FAA)
2. Concrete Formwork
3. Concrete Reinforcement
4. Structural Portland Cement Concrete
5. Underground Ducts and Manholes
6. Airport Airfield Lighting and Signs

b. Quality assurance.

1. Sampling and testing for compliance with the Contract provisions shall be in accordance as outlined in this section. The Subcontractor shall provide copies of the results of tests to the RPR. Tests conducted for the sole benefit of the Subcontractor shall be at the Subcontractor's expense.

2. Qualifications of the Testing Laboratory: The Subcontractor's testing laboratory used to develop the concrete mix design and perform required tests, inspections and certifications as specified shall meet the requirements of ASTM C1077, including accreditation. The laboratory accreditation will include ASTM C78. A certification that it meets these requirements shall be submitted to the RPR prior to the start of mix design and shall contain as a minimum:

   a. Qualifications of personnel: laboratory manager, supervising technician, and testing technicians.

   b. A statement that the equipment used in developing the mix design is in calibration.

   c. A statement that each test specified in developing the mix design is offered in the scope of the laboratory's services.

   d. A copy of the laboratory's quality control system.

3. Qualifications of Manufacturer: Ready-mixed concrete plants shall be approved and certified by the NRMCA. Ready-mix concrete shall be batched in accordance with the applicable portions of ASTM C94.

   Portable batch plants shall meet the requirements of ASTM C94, if utilized, shall be inspected and certified by a recognized independent testing laboratory selected and paid for by the Subcontractor. Copies of the inspection test report and certification shall be submitted to the RPR prior to production of concrete for this project.

For smaller quantities, hand batching will be allowed with strict adherence to the individual component batch proportions. The use of volumetric mixers will be allowed as long as batching tolerances are maintained.

4. Qualifications of Workmen:

   a. Provide at least one person, thoroughly trained and experienced in placing the types of concretes specified, who shall be present at all times during execution of this portion of the work and shall direct all work performed under this section.

   b. Thoroughly trained and experienced journeyman concrete finishers shall be responsible for finishing of exposed surfaces.

c. Submittals. The following submittals shall be submitted:

1. Testing Lab: Prior to start of the mix design, submit the certification of qualifications for the testing laboratory used to develop the mix design.

2. Mix Design: Submit mix design in accordance to the requirements listed in paragraph 611-3.5.

MATERIALS

611-2.1 General. Only approved materials, conforming to the requirements of these specifications, shall be used in the work. They may be subjected to inspection and tests at any time during the progress of their preparation or use. The source of supply of each of the materials shall be approved by the RPR before delivery or use is started. Representative preliminary samples of the materials shall be submitted by the Subcontractor, when required, for examination and test. Materials shall be scored and handled to insure the 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 therein.

In no case shall the use of pit run or naturally mixed aggregates be permitted. Naturally mixed aggregate shall be screened and washed, and all fine and coarse aggregates shall be stored separately and kept clean. The mixing of different kinds of aggregates from different sources in one storage pile or alternating batches of different aggregates will not be permitted.

611-2.2 Coarse aggregate. Mixes prepared for base can and conduit installation will use “pea gravel” (3/8” minus) as an extender per the manufacturer’s recommendations.

Coarse aggregate utilized for pavement repairs shall conform to the requirements of ASTM C33. Gradation within the separated size groups, shall meet the requirements of Table 1 when tested in accordance with ASTM C136.

TABLE 1. GRADATION FOR COARSE AGGREGATE ASTM C33

Sieve Designations (square openings)		Percentage by Weight Passing Sieves
in.	mm	3/4"-No.4
1	25.0	100
3/4	19.0	90-100
1/2	12.5	---
3/8	9.5	20-55
No. 4	4.75	0-10
No. 8	2.36	0-5

611-2.3 Fine aggregate. Fine aggregate for pavement repair concrete mixes shall conform to the requirements of ASTM C33 and shall meet the requirements of Table 2.

TABLE 2. GRADATION FOR FINE AGGREGATE

(ASTM C 33)

Sieve Designation (Square Openings)	Percentage by Weight Passing Sieves
3/8 in. (9.5 mm)	100
No. 4 (4.75 mm)	95-100
No. 8 (2.36 mm)	80-100
No. 16 (1.18 mm)	50-85
No. 30 (600 micro-m)	25-60
No. 50 (300 micro-m)	10-30
No. 100 (150 micro-m)	2-10

The fineness Modulus of the Fine Aggregate shall be a minimum of 2.95.

611-2.4 Aggregate reactivity. The aggregate supplier shall provide a statement or test data showing that the aggregate supplied has not exhibited a history of reactivity, as tested in accordance with ASTM C1260.

611-2.5 Cement. Cement shall be “Rapid Set C-150 Cement” as manufactured by the CTS Cement Manufacturing Company, or an approved equal.

All cement shall be the product of one manufacturer. If, for any reason, 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.

611-2.6 Water. The water used in concrete shall be free from sewage, oil, acid, strong alkalies, vegetable matter and clay and loam. If the water is of questionable quality, it shall be tested in accordance with AASHTO T 26.

611-2.7 Cementitious materials. Fly ash shall meet the requirements of ASTM C618, Class C, F, or N with the exception of loss of ignition, where the maximum shall be less than 6 percent for Class F or N. Fly ash such as is produced in furnace operations utilizing liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The Subcontractor shall furnish vendor's certified test reports for each shipment of Fly Ash used in the project. The vendor's certified test report can be used for acceptance or the material may be tested independently by the RPR.

611-2.8 Admixtures. The use of any material added to the concrete mix shall be approved by the RPR. Before approval of any material, the Contractor shall be required to submit the results of complete physical and chemical analyses made by an acceptable testing laboratory. Subsequent tests shall be made of samples taken by the RPR 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.

Pozzolanic admixtures shall be fly ash or raw or calcined natural pozzolans meeting the requirements of ASTM C618.

Air entraining admixtures shall meet the requirements of ASTM C260. Air entraining admixtures shall be added at the mixer in the amount necessary to produce the specified air content.

Water reducing, set controlling admixtures shall meet the requirements of ASTM C494, Type A, water reducing or Type D, water reducing and retarding. Water reducing admixtures shall be added at the mixer separately from air entraining admixtures in accordance with the manufacturer's printed instructions.

611-2.9 Steel reinforcement. Reinforcing shall meet the requirements of Item P-610-2.10– Steel Reinforcement.

611-2.10 Dowel and tie bars. Tie bars shall be deformed steel bars and conform to the requirements of ASTM A615 or ASTM A996, except that rail steel bars, Grade 50 or 60, shall not be used for tie bars that are to be bent or re-straightened during construction. Tie bars designated as Grade 40 in ASTM A615 can be used for construction requiring bent bars.

Dowel bars shall be plain steel bars conforming to ASTM A615 or ASTM A966 and shall be free from burring or other deformation restricting slippage in the concrete. High strength dowel bars shall conform to ASTM A714, Class 2, Type S, Grade I, II or III, Bare Finish. Before delivery to the construction site each dowel bar shall be painted with one coat of paint conforming to MIL-DTL-24441/20A.SSPC Paint 5 or SSPC Paint 25.Metal or plastic collars shall be full circular device supporting the dowel until the epoxy hardens.

MIX DESIGN AND TEST SECTIONS

611-3.1 General. The mix shall be designed using the procedures contained in Chapter 7 of the Portland Cement Association's manual, "Design and Control of Concrete Mixtures". Flexural strength test specimens shall be prepared in accordance with ASTM C31 and tested in accordance with ASTM C78. The testing laboratory providing the mix design and testing services shall meet the requirements of Subsection 611-1.1B.

No change shall be made in an approval mix design without prior written authorization from the RPR. If a change in sources is made, or admixtures are added or deleted from the mix, a new mix design must be submitted to the RPR for approval.

611-3.2 Strength and proportions. A mix design shall be developed by the Subcontractor to meet the following properties:

A. The concrete mix shall achieve a minimum flexural strength of 550 psi within 4 hours of the time the water is added to the mix, and shall achieve a minimum flexural strength of 650 psi in 7 days for mixes developed for pavement panel repairs.

B. Mixes developed for installation of base cans and conduit shall achieve a minimum compressive strength of 3500 psi in 2 hours and a minimum compressive strength of 6000 psi in 7 days

C. The concrete placed each night must attain the 550 psi flexural strength by the pavement opening time indicated on the phasing plans when pavement replacement is being performed or 3500 psi compressive when base cans or conduit installation activities are being performed.

D. The concrete mix shall have set time of a minimum 30 minutes longer than the time established by the Subcontractor procedure to batch, transport and place the concrete mix at the work site. The set time shall be defined as the time at which the mix takes to set and no further surface finishing can be accomplished

E. The proportions of the concrete mix shall be as developed by the Subcontractor to meet the specified criteria. There is no specified minimum cement content, slump, water/cement ration or restriction on admixtures.

611-3.3 Cementitious materials. Fly ash shall only be permitted as recommended and specifically provided for by the cementitious material manufacturer.

611-3.4 Admixtures. As specified in Item P-610– Portland Cement Concrete Pavement, with the exception of the following for pavement panel repair mixes:

A. **Air entraining.** The average air content shall be 4.5 percent, plus or minus 1.0 percent, and the mix shall have a durability factor of 95 or more when tested in accordance with ASTM C666. The durability factor shall be determined by a test of the actual concrete mix to be used on the project.

611-3.5 Mix design development and submittal. The Subcontractor shall develop a mix design that meets the criteria specified in paragraph 611-3.2. The process shall include the development of a minimum of three trial batches with decreasing water/cement ratios. The batches shall use the intended raw materials to be used for the project, including cement, fine and coarse, fine and coarse aggregates, as well as chemical and mineral admixtures. The trial batch mixtures shall maintain the same fine aggregate ratios as well as the same proportions of intended admixtures, only the water/cement ratio shall be varied. The testing of the trial batches shall, at a minimum, include flexural strength, air content and slump. Flexural and compressive specimens shall be prepared in accordance with ASTM C31, except that specimens shall be surrounded with insulating blankets for a minimum of 4 hours following addition of water to the mix. The mix design to be submitted for use on the project shall be one of the trail batches.

611-3.6 Strength samples. As noted above, the appropriate mix (either compressive or flexural) shall be submitted to the RPR for approval.

Mix Design Submittal. The mix design submittal shall include the following minimum information:

1. Type(s) of cement.
2. Water/Cement ratio.
3. Slump.
4. Air Entrainment percentage.
5. Flexural or compressive strength test results at 1, 2, 3, 4, 6 and 24 hours, and 2, 3, 4, and 7 days.
6. Results of durability test in accordance with ASTM C 666.
7. Plant/lab mix certification of proportion of materials.
8. Fine and coarse aggregate supplier, pit location, gradation, fineness modulus, tested wear, specific gravity, absorption capacity and moisture content.
9. Manufacturer’s name, catalog information for the cement(s) and admixtures used, including ASTM certification information.
10. Certification of testing Laboratory designing the mix.

CONSTRUCTION METHODS

611-4.1 General. The Subcontractor shall furnish all labor, materials and services necessary for, and incidental to, the completion of all work as shown on the drawings and specified herein. All machinery and equipment owned or controlled by the Subcontractor, which he proposes to use on the work, shall be of sufficient size to meet the requirements of the work and shall be such as to produce satisfactory work; all work shall be subject to the inspection and approval of the RPR.

The Subcontractor shall have a technical representative from the cement manufacturer on site for a minimum of the first three shifts that the mix is utilized in the field to ensure conformance with the intended use of the product.

611-4.2 Acceptance sampling and testing. Concrete samples shall be furnished by the Subcontractor and shall be taken in the field to determine the consistency, air content and strength of the concrete. Samples for strength testing shall be made each night that the concrete is placed. The specimens shall be made in accordance with ASTM C31. A minimum of two flexural strength test beams or compressive test cylinders shall be molded from the same batch of concrete and tested at the time scheduled for opening the pavement surface. Additional test specimens shall be made, at the Subcontractor's expense, to ensure there are adequate test samples available to show compliance with the specification.

For each day of placement, the average strength of the concrete tested shall be not less than 550 psi (flexural) or 3500 psi (compressive) as applicable at the time the pavement is scheduled for opening to normal airport traffic.

The Subcontractor shall provide, cure, and test the specimens.

611-4.3 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 RPR and shall provide means of regulating the flow of aggregates into the batch box so that the required and exact weight of aggregates can be readily obtained.

611-4.4 Consistency. The consistency of the concrete shall be checked by the slump test specified in ASTM C143.

611-4.5 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.

611-4.6 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 the minimum temperature specified by the manufacturer.

Retempering of concrete by adding water or any other material shall not be permitted. The delivery of concrete to the job shall be in such a manner that batches of concrete will be deposited at uninterrupted intervals.

611-4.7 Forms. Concrete shall not be placed until all the forms and reinforcements have been inspected and approved by the RPR. Forms shall be of suitable material and shall be of the type, size, shape, quality and strength to build the structure as designed 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 Subcontractor shall bear responsibility for their adequacy. The surfaces of forms shall be smooth and free from irregularities, dents, sags and holes.

The internal ties shall be arranged so that, when the forms are removed, no metal will show in the concrete surface or discolor the surface when exposed to weathering. All forms shall be wetted with water or with a

non-staining mineral oil which shall be applied shortly before the concrete is placed. Forms shall be constructed so that they can be removed without injuring the concrete or concrete surface.

611-4.8 Placing reinforcement. All reinforcement shall be accurately placed, as shown on the plans and shall be firmly held in position during concreting. 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 Subcontractor when required.

611-4.9 Embedded items. Before placing concrete, any items that are to be embedded shall be firmly and securely fastened in place as indicated. All such items shall be clean and free from coating, rust, scale, oil, or any foreign matter. The embedding of wood shall not be permitted. The concrete shall be spaded and consolidated around and against embedded items.

611-4.10 Placing concrete. The concrete shall not be placed until the depth and character of foundation, the adequacy of forms and falsework and the placing of the steel reinforcing have been approved. Concrete shall be placed as soon as practical after mixing. The method and manner of placing shall be such to avoid segregation and displacement of the reinforcement. Troughs, pipes and chutes shall be used as an aid in placing concrete when necessary. Dropping the concrete a distance of more than 5 feet, or depositing a large quantity at one point, will not be permitted. Concrete shall be placed upon clean, damp surfaces, free from running water, or upon properly consolidated soil.

The concrete shall be compacted with suitable mechanical vibrators operating within the concrete. When necessary, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction. Vibrators shall be manipulated so as to work the concrete thoroughly around the reinforcement and embedded fixtures and into corners and angles of the forms. The vibration at any joint shall be of sufficient duration to accomplish compaction but shall not be prolonged to the point where segregation occurs.

611-4.11 Joints. Joints shall be constructed at such points and of such dimensions as may be indicated on the drawings. The premolded filler shall be cut to the same shape as that of the surfaces being joined. The filler shall be fixed firmly against the surface of the concrete already in place in such manner that it will not be displaced when concrete is deposited against it.

611-4.12 Defective work. Any defective work shall be removed and replaced. Failure to attain the specified flexural strength at the time of pavement surface opening or the 7 day requirement will require the work to be removed and replaced at no cost to the Airport. If any dimensions are deficient, or if the surface of the concrete is bulged, uneven, or shows honeycomb, the entire section shall be removed and replaced at no cost to the Airport.

611-4.13 Surface finish. All exposed concrete surfaces shall be true, smooth, and free from open or rough spaces, depressions, or projections. The concrete in horizontal plane surfaces shall be brought flush with the finished top surface at the proper elevation and shall be 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.

When directed, 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 pointed and 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 rubbing machine.

For concrete surfaces subjected to aircraft, vehicular or foot traffic, a type of brush or broom finish shall be applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 1/16 of an inch in depth.

611-4.14 Curing and protection. The initial method of curing, to begin immediately after the finishing and set of the pavement surface, shall be water curing when rapid-set mixes are used. The entire surface shall be kept continuously moist by sprinkling for at least 2 hours, or longer if recommended by the cement manufacturer or mix designer. After the initial curing period is completed, a white-pigmented curing compound shall be applied conforming to the following specification: Liquid Membrane – Forming Compounds for Curing Concrete ASTM C309, Type 2.

METHOD OF MEASUREMENT

611-5.1 No separate measurement will be made for Quick Setting High Early Strength Structural Cement Concrete when utilized for backfilling of conduit trenches or base can installations. In these instances, the mix shall be considered incidental to the installation of the other equipment.

When utilized for full or partial panel replacement of Portland cement concrete pavement, the number of cubic yards of paving installed and accepted will be measured.

BASIS OF PAYMENT

611-6.1 No separate payment will be made for Quick Setting High Early Strength Structural Cement Concrete when utilized for backfilling of conduit trenches and base cans. The cost of this portion of the work shall be included in the payments made for the applicable bid items in the Schedules of Unit Prices.

Payment will be made for the number of cubic yards of pavement replacement installed and accepted and shall be considered full payment for all materials, labor and equipment necessary to complete the pavement repair.

Payment will be made under:

Item P-611-6.1 Concrete Pavement Repairs - per cubic yard

TESTING REQUIREMENTS

ASTM C 31 Making and Curing Test Specimens in the Field

ASTM C 39 Compressive Strength of Cylindrical Concrete Specimens

ASTM C 136 Sieve Analysis of Fine and Coarse Aggregate

ASTM C 138 Unit Weight, Yield and Air Content of Concrete

ASTM C 143 Slump of Hydraulic Cement Concrete

ASTM C 231 Air Content of Freshly Mixed Concrete by the Pressure Method

MATERIAL REQUIREMENTS

ASTM A 184 Specification for Fabricated Deformed Steel Bar or Rod Mats for Concrete Reinforcement

ASTM A 185 Steel Welded Wire Fabric Plain for Concrete Reinforcement

ASTM A 497 Specification for Welded Deformed Steel Wire Fabric for Concrete Reinforcement

ASTM A 615 Deformed and Plain Billet Steel Bars for Concrete Reinforcement

ASTM C 33 Concrete Aggregates

ASTM C 94	Ready Mixed Concrete
ASTM C 150	Portland Cement
ASTM C 171	Sheet Materials for Curing Concrete
ASTM C 260	Air Entraining Admixtures for Concrete
ASTM C 309	Liquid Membrane Forming Compounds for Curing Concrete
ASTM C 595	Blended Hydraulic Cements
ASTM C 618	Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
ASTM C 1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM D 1751	Specification for Performed Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 1752	Specification for Performed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

END OF ITEM P-611

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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 Resident Project Representative (RPR). The terms "paint" and "marking material" as well as "painting" and "application of markings" are interchangeable throughout this specification.

MATERIALS

620-2.1 Materials acceptance. The Contractor shall furnish manufacturer's certified test reports, for materials shipped to the project. The certified test reports shall include a statement that the materials meet the specification requirements. This certification along with a copy of the paint manufacturer's surface preparation; marking materials, including adhesion, flow promoting and/or floatation additive; and application requirements must be submitted and approved by the Resident Project Representative (RPR) prior to the initial application of markings. The reports can be used for material acceptance or the RPR may perform verification testing. The reports shall not be interpreted as a basis for payment. The Contractor shall notify the RPR upon arrival of a shipment of materials to the site. All material shall arrive in sealed containers that are easily quantifiable for inspection by the RPR.

620-2.2 Marking materials.

Table 1. Marking Materials

Paint[1]				Glass Beads[2]	
Type	**Color**	**Fed Std. 595 Number**	**Application Rate Maximum**	**Type**	**Application Rate Minimum**
Waterborne Type I	White	37925	115 ft^2/gal	Type I, Gradation A	7 lb/gal
Waterborne Type I	Yellow	33538 or 33655	115 ft^2/gal	Type I, Gradation A or III where indicated	7 lb/gal or 10 lb/gal
Waterborne Type I	Red	31136	115 ft^2/gal	Type I, Gradation A	5 lb/gal
Waterborne Type I	Pink	1 part 31136 to 2 parts 37925	115 ft^2/gal	Type I, Gradation A	5 lb/gal
Waterborne Type I	Black	37038	115 ft^2/gal	None	None

[1] See paragraph 620-2.2a

[2] See paragraph 620-2.2b

a. Paint. Paint shall be waterborne in accordance with the requirements of this paragraph. Paint colors shall comply with Federal Standard No. 595.**Waterborne.** Paint shall meet the requirements of

Federal Specification TT-P-1952F, Type I. 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.

b. Reflective media. Glass beads for white and yellow paint shall meet the requirements for Federal Specification TT-B-1325D Type I, Gradation A.

Glass beads for red and pink paint shall meet the requirements for Type I, Gradation A.

Glass beads shall be treated with all compatible coupling agents recommended by the manufacturers of the paint and reflective media to ensure adhesion and embedment.

Glass beads shall not be used in black and green paint.

Type III glass beads shall not be used in red and pink paint.

CONSTRUCTION METHODS

620-3.1 Weather limitations. Painting shall only be performed when the surface is dry, and the ambient temperature and the pavement surface temperature meet the manufacturer's recommendations in accordance with paragraph 620-2.1. Painting operations shall be discontinued when the ambient or surface temperatures does not meet the manufacturer's recommendations. Markings shall not be applied when the wind speed exceeds 10 mph unless windscreens are used to shroud the material guns. Markings shall not be applied when weather conditions are forecasts to not be within the manufacturers' recommendations for application and dry time.

620-3.2 Equipment. Equipment shall include the apparatus necessary to properly clean the existing surface, a mechanical marking machine, a bead dispensing machine, and such auxiliary hand-painting equipment as may be necessary to satisfactorily complete the job.

The mechanical marker shall be an atomizing spray-type or airless type marking machine with automatic glass bead dispensers suitable for application of traffic paint. It shall produce an even and uniform film thickness and appearance of both paint and glass beads at the required coverage and shall apply markings of uniform cross-sections and clear-cut edges without running or spattering and without over spray. The marking equipment for both paint and beads shall be calibrated daily.

620-3.3 Preparation of surfaces. Immediately before application of the paint, the surface shall be dry and free from dirt, grease, oil, laitance, or other contaminates that would reduce the bond between the paint and the pavement. Use of any chemicals or impact abrasives during surface preparation shall be approved in advance by the RPR. 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.

a. Preparation of new pavement surfaces. The area to be painted shall be cleaned by broom, blower, water blasting, or by other methods approved by the RPR to remove all contaminants, including PCC curing compounds, minimizing damage to the pavement surface.

b. Preparation of pavement to remove existing markings. Existing pavement markings shall be removed by rotary grinding, water blasting, or by other methods approved by the RPR minimizing damage to the pavement surface. The removal area may need to be larger than the area of the markings to eliminate ghost markings. After removal of markings on asphalt pavements, apply a fog seal or seal coat to 'block out' the removal area to eliminate 'ghost' markings.

c. Preparation of pavement markings prior to remarking. Prior to remarking existing markings, loose existing markings must be removed minimizing damage to the pavement surface, with a method approved by the RPR. After removal, the surface shall be cleaned of all residue or debris.

Prior to the application of markings, the Contractor shall certify in writing that the surface is dry and free from dirt, grease, oil, laitance, or other foreign material that would prevent the bond of the paint to the pavement or existing markings. This certification along with a copy of the paint manufactures application and surface preparation requirements must be submitted to the RPR prior to the initial application of markings.

620-3.4 Layout of markings. The proposed markings shall be laid out in advance of the paint application. The locations of markings to receive glass beads shall be shown on the plans.

620-3.5 Application. A period of 3 days shall elapse between placement of surface course or seal coat and application of the permanent paint markings. Paint shall be applied at the locations and to the dimensions and spacing shown on the plans. Paint shall not be applied until the layout and condition of the surface has been approved by the RPR.

The edges of the markings shall not vary from a straight line more than 1/2 inch in 50 feet, and marking dimensions and spacing shall be within the following tolerances:

Marking Dimensions and Spacing Tolerance

Dimension and Spacing	Tolerance
36 inch or less	±1/2 inch
greater than 36 inch to 6 feet	±1 inch
greater than 6 feet to 60 feet	±2 inch
greater than 60 feet	±3 inch

The paint shall be mixed in accordance with the manufacturer's instructions and applied to the pavement with a marking machine at the rate shown in Table 1. The addition of thinner will not be permitted.

Glass beads shall be distributed upon the marked areas at the locations shown on the plans to receive glass beads immediately after application of the paint. A dispenser shall be furnished that is properly designed for attachment to the marking machine and suitable for dispensing glass beads. Glass beads shall be applied at the rate shown in Table 1. Glass beads shall not be applied to black paint or green paint. Glass beads shall adhere to the cured paint or all marking operations shall cease until corrections are made. Different bead types shall not be mixed. Regular monitoring of glass bead embedment and distribution should be performed.

620-3.6 Application--preformed thermoplastic airport pavement markings. Preformed thermoplastic pavement markings not used.

620-3.7 Control strip. Prior to the full application of airfield markings, the Contractor shall prepare a control strip in the presence of the RPR. The Contractor shall demonstrate the surface preparation method and all striping equipment to be used on the project. The marking equipment must achieve the prescribed application rate of paint and population of glass beads (per Table 1) that are properly embedded and evenly distributed across the full width of the marking. Prior to acceptance of the control strip, markings must be evaluated during darkness to ensure a uniform appearance.

620-3.8 Retro-reflectance. Reflectance shall be measured with a portable retro-reflectometer meeting ASTM E1710 (or equivalent). A total of 6 reading shall be taken over a 6 square foot area with 3 readings taken from each direction. The average shall be equal to or above the minimum levels of all readings which are within 30% of each other.

Minimum Retro-Reflectance Values

Material	Retro-reflectance mcd/m^2/lux		
	White	Yellow	Red
Initial Type I	300	175	35
Initial Type III	600	300	35
Initial Thermoplastic	225	100	35
All materials, remark when less than[1]	100	75	10

[1] 'Prior to remarking determine if removal of contaminants on markings will restore retro-reflectance

620-3.9 Protection and cleanup. After application of the markings, all markings shall be protected from damage until dry. All surfaces shall be protected from excess moisture and/or rain and from disfiguration by spatter, splashes, spillage, or drippings. The Contractor shall remove from the work area all debris, waste, loose reflective media, and by-products generated by the surface preparation and application operations to the satisfaction of the RPR. The Contractor shall dispose of these wastes in strict compliance with all applicable state, local, and federal environmental statutes and regulations.

METHOD OF MEASUREMENT

620-4.1a The quantity of markings shall be measured by the number of square feet of painting.

620-4.1b The quantity of reflective media shall be incidental to markings.

BASIS OF PAYMENT

620-5.1 This price shall be full compensation for furnishing all materials and for all labor, equipment, tools, and incidentals necessary to complete the item complete in place and accepted by the RPR in accordance with these specifications.

620-5.2a Payment for markings shall be made at the contract price for the number of square feet of painting.

620-5.3b Payment for reflective media shall be incidental to markings.

Payment will be made under:

Item P-620-5.1 Runway and Taxiway Marking – per square foot

REFERENCES

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

ASTM International (ASTM)

ASTM D476	Standard Classification for Dry Pigmentary Titanium Dioxide Products
ASTM D968	Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM D1652	Standard Test Method for Epoxy Content of Epoxy Resins
ASTM D2074	Standard Test Method for Total, Primary, Secondary, and Tertiary Amine Values of Fatty Amines by Alternative Indicator Method
ASTM D2240	Standard Test Method for Rubber Property - Durometer Hardness
ASTM D7585	Standard Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments
ASTM E303	Standard Test Method for Measuring Surface Frictional Properties Using the British Pendulum Tester
ASTM E1710	Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer
ASTM E2302	Standard Test Method for Measurement of the Luminance Coefficient Under Diffuse Illumination of Pavement Marking Materials Using a Portable Reflectometer
ASTM G154	Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

Code of Federal Regulations (CFR)

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
29 CFR Part 1910.1200	Hazard Communication

Federal Specifications (FED SPEC)

FED SPEC TT-B-1325D	Beads (Glass Spheres) Retro-Reflective
FED SPEC TT-P-1952F	Paint, Traffic and Airfield Marking, Waterborne
FED STD 595	Colors used in Government Procurement

Commercial Item Description

A-A-2886B	Paint, Traffic, Solvent Based

Advisory Circulars (AC)

AC 150/5340-1	Standards for Airport Markings
AC 150/5320-12	Measurement, Construction, and Maintenance of Skid Resistant Airport Pavement Surfaces

END OF ITEM P-620

Item T-904 Sodding

DESCRIPTION

904-1.1 This item shall consist of furnishing, hauling, and placing approved live sod on prepared areas in accordance with this specification at the locations shown on the plans or as directed by the RPR.

MATERIALS

904-2.1 Sod. Sod furnished by the Contractor shall have a good cover of living or growing grass. This shall be interpreted to include grass that is seasonally dormant during the cold or dry seasons and capable of renewing growth after the dormant period. All sod shall be obtained from areas where the soil is reasonably fertile and contains a high percentage of loamy topsoil. Sod shall be cut or stripped from living, thickly matted turf relatively free of weeds or other undesirable foreign plants, large stones, roots, or other materials that might be detrimental to the development of the sod or to future maintenance. At least 70% of the plants in the cut sod shall be composed of the species stated in the special provisions, and any vegetation more than 6 inches in height shall be mowed to a height of 3 inches or less before sod is lifted. Sod, including the soil containing the roots and the plant growth showing above, shall be cut uniformly to a thickness not less than that stated in the special provisions.

904-2.2 Lime. Lime shall be ground limestone containing not less than 85% of total carbonates, and shall be ground to such fineness that 90% will pass through a No. 20 mesh sieve and 50% will pass through a No. 100 mesh sieve. Coarser material will be acceptable, providing the rates of application are increased to provide not less than the minimum quantities and depth specified in the special provisions on the basis of the two sieve requirements above. Dolomitic lime or a high magnesium lime shall contain at least 10% of magnesium oxide. Lime shall be applied at the rate of 4,000 lb/acre. All liming materials shall conform to the requirements of ASTM C602.

904-2.3 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 13-13-13 commercial fertilizer and shall be spread at the rate of 1,000 lbs/acre to a minimum depth of 3 inches.

904-2.4 Water. The water shall be sufficiently free from oil, acid, alkali, salt, or other harmful materials that would inhibit the growth of grass.

904-2.5 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 RPR before being placed.

CONSTRUCTION METHODS

904-3.1 General. Areas to be solid, strip, or spot sodded shall be shown on the plans. Areas requiring special ground surface preparation such as tilling and those areas in a satisfactory condition that are to remain undisturbed shall also be shown on the plans.

Suitable equipment necessary for proper preparation of the ground surface and for the handling and placing of all required materials shall be on hand, in good condition, and shall be approved by the RPR before the various operations are started. The Contractor shall demonstrate to the RPR before starting the various operations that the application of required materials will be made at the specified rates.

904-3.2 Preparing the ground surface. After grading of areas has been completed and before applying fertilizer and limestone, areas to be sodded shall be raked or otherwise cleared of stones larger than 2 inches in any diameter, sticks, stumps, and other debris which might interfere with sodding, growth of grasses, or subsequent maintenance of grass-covered areas. If any damage by erosion or other causes occurs after grading of areas and before beginning the application of fertilizer and ground limestone, the Contractor shall repair such damage. This may include filling gullies, smoothing irregularities, and repairing other incidental damage.

904-3.3 Applying fertilizer and ground limestone. Following ground surface preparation, fertilizer shall be uniformly spread at a rate which will provide not less than the minimum quantity of each fertilizer ingredient, as stated in the special provisions. If use of ground limestone is required, it shall then be spread at a rate that will provide not less than the minimum quantity stated in the special provisions. These materials shall be incorporated into the soil to a depth of not less than 2 inches by discing, raking, or other suitable methods. Any stones larger than 2 inches in any diameter, large clods, roots, and other litter brought to the surface by this operation shall be removed.

904-3.4 Obtaining and delivering sod. After inspection and approval of the source of sod by the RPR, the sod shall be cut with approved sod cutters to such a thickness that after it has been transported and placed on the prepared bed, but before it has been compacted, it shall have a uniform thickness of not less than 2 inches. Sod sections or strips shall be cut in uniform widths, not less than 10 inches, and in lengths of not less than 18 inches, but of such length as may be readily lifted without breaking, tearing, or loss of soil. Where strips are required, the sod must be rolled without damage with the grass folded inside. The Contractor may be required to mow high grass before cutting sod.

The sod shall be transplanted within 24 hours from the time it is stripped, unless circumstances beyond the Contractor’s control make storing necessary. In such cases, sod shall be stacked, kept moist, and protected from exposure to the air and sun and shall be kept from freezing. Sod shall be cut and moved only when the soil moisture conditions are such that favorable results can be expected. Where the soil is too dry, approval to cut sod may be granted only after it has been watered sufficiently to moisten the soil to the depth the sod is to be cut.

904-3.5 Laying sod. Sodding shall be performed only during the seasons when satisfactory results can be expected. Frozen sod shall not be used and sod shall not be placed upon frozen soil. Sod may be transplanted during periods of drought with the approval of the RPR, provided the sod bed is watered to moisten the soil to a depth of at least 4 inches immediately prior to laying the sod.

The sod shall be moist and shall be placed on a moist earth bed. Pitch forks shall not be used to handle sod, and dumping from vehicles shall not be permitted. The sod shall be carefully placed by hand, edge to edge and with staggered joints, in rows at right angles to the slopes, commencing at the base of the area to be sodded and working upward. The sod shall immediately be pressed firmly into contact with the sod bed by tamping or rolling with approved equipment to provide a true and even surface, and ensure knitting without displacement of the sod or deformation of the surfaces of sodded areas. Where the sod may be displaced during sodding operations, the workmen, when replacing it, shall work from ladders or treaded planks to prevent further displacement. Screened soil of good quality shall be used to fill all

cracks between sods. The quantity of the fill soil shall not cause smothering of the grass. Where the grades are such that the flow of water will be from paved surfaces across sodded areas, the surface of the soil in the sod after compaction shall be set approximately one inch below the pavement edge. Where the flow will be over the sodded areas and onto the paved surfaces around manholes and inlets, the surface of the soil in the sod after compaction shall be placed flush with pavement edges.

On slopes steeper than one (1) vertical to 2-1/2 horizontal and in v-shaped or flat-bottom ditches or gutters, the sod shall be pegged with wooden pegs not less than 12 inches in length and have a cross-sectional area of not less than 3/4 sq inch. The pegs shall be driven flush with the surface of the sod.

904-3.6 Watering. Adequate water and watering equipment must be on hand before sodding begins, and sod shall be kept moist until it has become established and its continued growth assured. In all cases, watering shall be done in a manner that will avoid erosion from the application of excessive quantities and will avoid damage to the finished surface.

904-3.7 Establishing turf. The Contractor shall provide general care for the sodded areas as soon as the sod has been laid and shall continue until final inspection and acceptance of the work. All sodded areas shall be protected against traffic or other use by warning signs or barricades approved by the RPR. The Contractor shall mow the sodded areas with approved mowing equipment, depending upon climatic and growth conditions and the needs for mowing specific areas. Weeds or other undesirable vegetation shall be mowed and the clippings raked and removed from the area.

904-3.8 Repairing. When the surface has become gullied or otherwise damaged during the period covered by this contract, the affected areas shall be repaired to re-establish the grade and the condition of the soil, as directed by the RPR, and shall then be sodded as specified in paragraph 904-3.5.

METHOD OF MEASUREMENT

904-4.1 This item shall be measured on the basis of the area in square yards of the surface covered with sod and accepted.

BASIS OF PAYMENT

904-5.1 This item will be paid for on the basis of the contract unit price per square yard for sodding, which price shall be full compensation for all labor, equipment, material, staking, and incidentals necessary to satisfactorily complete the items as specified.

Payment will be made under:

Item T-904-5.1	Sodding - per square yard

REFERENCES

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

ASTM International (ASTM)

ASTM C602	Standard Specification for Agricultural Liming Materials

Advisory Circulars (AC)

AC 150/5200-33	Hazardous Wildlife Attractants on or Near Airports

FAA/United States Department of Agriculture

Wildlife Hazard Management at Airports, A Manual for Airport Personnel

END OF ITEM T-904

Item T-905 Topsoil

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 RPR.

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 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. Ordinary sod and herbaceous growth such as grass and weeds are not to be removed, but shall be thoroughly broken up and intermixed with the soil during handling operations. 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 5.5 pH to 7.6 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 3% nor more than 20% as determined by the wet-combustion method (chromic acid reduction). There shall be not less than 20% nor more than 80% of the material passing the 200 mesh sieve as determined by the wash test in accordance with ASTM C117.

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 RPR 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 RPR 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 RPR, to a minimum depth of 2 inches to facilitate bonding of the topsoil to the covered subgrade soil. The surface of the area to be topsoiled shall be cleared of all stones larger than 2 inches 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 RPR. 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 RPR. The topsoil shall be spread on areas already tilled and smooth-graded, or stockpiled in areas approved by the RPR. 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 topsoil 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 RPR. The Contractor shall notify the RPR 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.

905-3.4 Placing topsoil. The topsoil shall be evenly spread on the prepared areas to a uniform depth of 2 inches after compaction, unless otherwise shown on the plans or stated in the special provisions. 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 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 RPR. 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.

METHOD OF MEASUREMENT

905-4.1 Topsoil obtained on the site shall be measured by the number of cubic yards of topsoil measured in its original position and stripped or excavated. Topsoil stockpiled by others and removed for topsoil by the Contractor shall be measured by the number of cubic yards of topsoil measured in the stockpile. Topsoil shall be measured by volume in cubic yards computed by the method of end areas.

905-4.2 Topsoil obtained off the site shall be measured by the number of cubic yards of topsoil measured in its original position and stripped or excavated. Topsoil shall be measured by volume in cubic yards 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 for topsoil (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 for topsoil (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	Topsoil (4 inches thick) - per cubic yard

REFERENCES

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

ASTM International (ASTM)

ASTM C117	Materials Finer than 75 μm (No. 200) Sieve in Mineral Aggregates by Washing

Advisory Circulars (AC)

AC 150/5200-33	Hazardous Wildlife Attractants on or Near Airports

FAA/United States Department of Agriculture

Wildlife Hazard Management at Airports, A Manual for Airport Personnel

END OF ITEM T-905

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Item L-100 Airfield Electrical Work

DESCRIPTION

100-1.1 Summary. 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 install, airfield lighting fixtures, base cans, cabling, electrical conduit, duct banks, handholes, and all other electrical work as described herein and shown in the Contract Documents.

Work shall be in accordance with Federal Aviation Administration Advisory Circular No. 150/5370-10 "Standards for Specifying Construction of Airports," as modified herein, other FAA Advisory Circulars and Specifications referred to herein, and other requirements as specified herein.

100-1.2 References. Additional specifications pertaining to a specific system covered in this item are contained in the following FAA documents:

AC 150/5340-18	Standards for Airport Sign System
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-42	Specifications for Airport Light Bases, Transformer Housings, Junction Boxes, and Accessories
AC 150/5345-44	Specification for Taxiway and Runway Signs
AC 150/5345-46	Specifications for Runway and Taxiway Light Fixtures
AC 150/5345-47	Isolation Transformers for Airport Lighting System
FAA-STD-1217f	Electrical Work – Interior
FAA-STD-019g	Lighting and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment
FAA-STD-061	Airport Fiber Optic Transmission System (FOTS) Standards
FAA-E-2761c	Cable, fiber Optic, Multimode and Single-Mode, Multifiber
FAA-G-2100H	Electronic Equipment – General Requirements
FAA-C-1391b	Installation and Splicing of Underground Cables
FAA Order 6950.27	Electrical Power Policy Implementation at NAS Facilities
FAA Order 3900.19B	FAA Occupational Safety and Health Program

The electrical work shall comply with latest adopted editions, codes and standards applicable to this Contract as follows:

ANSI C2	National Electrical Safety Code
FAA	Advisory Circulars
NEC	National Electrical Code (NFPA No. 70 and No. 780) and any Local or State Supplements or Amendments
NECA	Standard for Installation
NEMA	Standard for Materials and Products
NFPA 101	Life Safety Code
UL	Underwriters Laboratories

WW-C-566 Conduit, Metal, Flexible

All materials furnished for this project shall be listed by Underwriters' Laboratories wherever UL has a listed standard for that material.

100-1.3 Submittals. Submit data for all electrical materials. The Contractor's submittals shall be submitted in electronic PDF format, tabbed by specification section. The Contractor shall include wiring diagrams, product data cut sheets, equipment dimensions, calculations, certified drawings and brochures, etc. of all equipment used on the job, showing compliance with the specifications.

The submittal shall consist of manufacturer's brochures and cut sheets describing the equipment and materials Contractor plans to incorporate in the work. These sheets shall be sequentially ordered by specification number with the reference specification number shown on each sheet. They shall be organized by the specification item number (L-108, L-110, etc.) with a divider sheet separating each item section. The submittal shall clearly show the equipment manufacturer's name, catalog number, size, type, and/or rating. The conformance to FAA criteria or other standards where called for shall be clearly indicated for each item. When used, Contractor shall mark on cut sheets such that they show all pertinent information by boldly circling all necessary data, as specified herein. Each sheet shall be dedicated to one piece of equipment. All drawings shall be to scale. Each submittal shall show on the cover the complete job name and number, date, Contractor's name, and the words: "Electrical Submittal."

Submittal shall be largely complete at first submittal. Long lead items may be submitted separately ahead of main submittal.

A. Samples of fittings, fixtures, cables, etc., may be requested by the Resident Project Representative (RPR) 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 RPR.

B. Substitutions of materials referenced herein is allowed when "or equal" is referenced. Any substitution shall be included and clearly marked "Substitution" in the submittal package.

C. Contract documents shall not be used for equipment submittals or maintenance and operation manuals.

100-1.4 General work requirements. The drawings are diagrammatic. Locations of equipment to be installed are shown in the drawings, but the actual installation will depend on field conditions, the nature of the equipment furnished, and compliance with FAA requirements. When conditions which adversely affect the installation become apparent, the RPR shall be notified in writing.

The Contractor shall provide task lighting for night work. Task lighting shall be adequate to accurately see the task being performed and to allow for inspection of the work. Refer to IES recommended illumination levels.

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 and about the project, 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 Airport and RPR.

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 RPR.

Provide temporary taxiway and obstruction lighting per Contract Documents and FAA AC 150/5370-2 and 70/7460-1 (latest versions) for taxiways disrupted by construction.

Guarantee complete system performance as required by the Performance and Maintenance Bond.

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 such parts.

100-1.5 Scope of work. The work to be performed shall include providing 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 work is in progress, including protection of airport personnel, aircraft, and vehicles; furnish and maintain temporary circuits and place augmented taxiway lighting into operation, unless directed otherwise by the RPR. Airfield lighting and signage on active runways and taxiways shall be operable each night, each day when poor weather conditions exist, and when the airport calls an emergency. Poor weather visibility may require postponement of a scheduled shutdown on any given day.

B. Furnish and install handholes at the locations shown.

C. Provide new duct banks and ducts to new and existing base cans, at the locations indicated and in accordance with Contract Documents, ready for installation of cables. Excavate and backfill trenches, install duct marker tape, guard wire, and duct markers.

D. Install new airfield L-868 light fixture base cans at locations indicated and in accordance with the Contract Documents.

E. Install new Runway Entrance Lights (REL) and Takeoff hold Lights (THL) on new and existing base cans at locations indicated and in accordance with the Contract Documents.

F. Provide new airfield lighting cable L-824C in accordance with specifications, at the locations shown on the plans. Test all complete circuit loops after installation of new cables.

G. Install Airport-Furnished Constant Current Regulator (CCR) in new shelters to power new RWSL fixtures. Provide all necessary items required to complete foregoing.

H. Install Government-Furnished Shelters at locations shown on drawings and provide utility power, meter bases and disconnects. Coordinate with the utility.

I. 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 such parts.

J. Coordinate work with the Airport, FAA and the RPR for operations restrictions.

K. All items of general work required, such as excavation, cutting, patching, splicing, repairing, replacing, etc., shall be included in this Contract and in accordance with the applicable specifications.

100-1.6 Existing conditions. Existing conditions shown on Contract Drawings are intended to provide existing airfield utilities information based on available information. There are no guarantees as to the accuracy of any information. Therefore, it is the Contractor's responsibility to verify all existing utilities and circuitry prior to beginning any work. Advise RPR of discrepancies or questions noted.

Existing conduit shown on plans show approximate locations only. Contractor must verify and coordinate existing site conditions. The bids shall include hand digging and all required rerouting in areas of existing conduits and/or cables.

Prior to construction, investigate site thoroughly and develop plan to reroute all conduit and wiring in area of new construction in order to maintain continuity of existing circuitry not modified under specific portion of work.

Special attention is called to the fact that the work involved is in connection with existing systems/facilities which must remain in operation while work is being performed. Work must be done in accordance with the schedule developed with the RPR, and submitted for approval. Request written permission and receive written approval from the RPR a minimum of 72 hours in advance of any shutdown of existing system. Perform work required at other than standard working hours where outages cannot be approved during regular working hours.

Existing active services (water, gas, sewer, electric) when encountered, shall be protected against damage. Do not prevent or disturb operation of active services which are to remain. If an active service is encountered which might require relocation, advise the RPR so that resolution can occur in a timely manner.

If any difference is found between the existing conditions and the drawings or specifications, the RPR shall be notified in writing immediately.

100-1.7 Permits. The Contractor shall procure and pay for all permits and fees prior to the start of any work.

100-1.8 Drawings. The drawings, which constitute an integral part of this Contract, shall serve as the working drawings. They indicate the extent and general layout of the new as well as existing lighting system including handholes, conduits, and arrangement of conductors. Field verification of scale dimensions is required to determine actual locations, distances, and elevations. No extra compensation will be allowed because of minor differences between work shown on the drawings and field conditions.

The Contractor shall check the Contract Documents and, if any portion of the work is found to be omitted, unclear, or in error, the Contractor shall immediately notify the RPR. The directions of the RPR shall be followed and the work completed accordingly.

The Contract Documents may be utilized in the preparation of the working drawings showing the permanent construction, as described herein.

The Contract Documents 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 Contract Documents or within the drawings or the specifications, the item or arrangements of better quality, greater quantity, or higher cost shall be included in the base bid.

Any discrepancies between the drawings and field conditions must be resolved with the RPR before proceeding. All agreements shall be verified in writing.

Detail dimensions shown on the Contract Documents are approximate and shall be field verified before construction. All differences shall be submitted to the RPR in writing before construction begins.

100-1.9 Record documents. The Contractor shall maintain the Contract Documents and Shop Drawings at the site, in good order, and annotated daily to show all changes made during the construction process. These shall be available to the RPR for examination. Contractor shall submit complete and accurate as-built record documents to the RPR prior to application for final payment.

100-1.10 Maintenance and operations. The Contractor shall provide the Airport with complete instructions in the proper care and operation of the equipment installed under this contract. This is considered as part of the final acceptance.

The Contractor shall also collect and assemble into each of six (6) hard cover books 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 RPR for transmission to the RPR.

100-1.11 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 his Surety for completion of the Project. The Electrical Safety Rules are as follows:

A. The Contractor shall be responsible for conforming with the safety requirements of Appendix 1 to the latest version of AC 150/5370-2.

B. 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.

C. Electrical circuits shall be considered de-energized only when one of the following conditions exists:

   1. Switches connecting subject circuit to the energy supply are observed in the OPEN position, with an air break, and safety tagged (padlocked) in the OPEN position;

   2. Electrically operated switches are visibly OPEN, blocked or racked in the OPEN position, and safety tagged OPEN;

   3. Whenever the supply circuit breaker is not visible and clearly identified, the circuit shall be grounded within sight of the work area. The ground connection shall be safety tagged before work begins thereon.

D. Use of Red Safety Tags.

   1. Safety tags shall be filled out and connected to any switch or equipment opened for protection of personnel working upon circuits connected thereto.

   2. 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.

   3. Equipment with a safety tag attached shall not be operated, and connections with a safety tag attached shall not be changed.

   4. Insulated cables, operated at over 300 volts to ground shall be handled when energized only with extreme caution, and only with rubber gloves tested to 15,000 volts.

   5. Insulated cables, which have been in operation, shall be cut only with a grounded cable shears, or shall be grounded by driving a grounded sharp tool through the shielding and the conductors before cutting.

6. All personnel working around energized electrical equipment operating at over 750 volts shall wear standard insulated, non-conducting hard hats, and shall wear no garments with metallic zipper fasteners.

E. Clean-up of scrap materials and waste by the Contractor shall be completed daily.

100-1.12 Construction sequencing. Coordinate shutdown of taxiways and runways with the Airport and the FAA through the RPR, and in accordance with the Phasing indicated in the Contract Documents. Coordinate work sequence to minimize airfield downtime.

100-1.13 Warranty. The Contractor shall provide a written 1-year warranty guaranteeing all work installed under this contract, unless required otherwise by these specifications.

The warranty shall cover all parts and labor against defective parts or workmanship necessary to repair or bring into proper operation any equipment including, but not limited to, transformers, base cans, fixtures, conduit system, pull boxes, and wiring devices.

100-1.14 Substantial completion. All specified work shall be complete prior to final observation of work, and all forms and other information requested, including maintenance manuals, shall be submitted to the RPR for approval.

MATERIALS

100-2.1 General. 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.

Equipment and materials covered by these and other referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when requested by the RPR. Whenever Underwriters Laboratories has a published standard applicable to the equipment furnished for this contract, the furnished equipment shall be listed by UL.

Specific reference in the Contract Documents to any article, device, product, material, fixture, form or type of construction, etc., by name, make or catalog number, with or without the words "or equal" shall be interpreted as establishing a standard of quality and shall not be construed as limiting competition. The Contractor may at his option, propose for consideration any article, device, product, material, fixture, form or type of constriction, which in his opinion is equal to that herein named.

Requests for written approval to substitute materials or equipment to those specified shall be submitted for approval to the RPR no later than ten (10) days before bids are taken. Requests shall be accompanied by samples, descriptive literature, and engineering information, as necessary to fully identify and appraise the product. No increase in the contract sum will be considered when requests are not approved. If the item is found to be equal, the RPR will issue an Addendum making it a part of the Contract Documents prior to bidding.

100-2.2 Hardware corrosion prevention. In order to prevent deterioration due to corrosion, all bolts, nuts, studs, washers, pins, terminals, frangible couplings, and similar fastenings and fittings shall be of an approved corrosion resisting material.

All hardware such as cap screws, set screws, tap bolts, nuts, washers, hinges, etc., shall be of stainless steel Type 316, SAE grade 2. All bolts, screws, nuts, etc., may require coating with a layer of "anti-seize" lubricating compound, depending on manufacturer recommendations. Fixture bolts shall be 18-8

stainless steel for galvanized steel base cans and SAE Grade 2 hex-head (plain steel) bolts using ceramic-metallic fluoropolymer coating for stainless steel base cans.

All ferrous metalwork shall be galvanized, or with improved protection as indicated in the Contract Documents. 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 degrees F to plus 120 degrees F.

B. Humidity. Up to 100 percent.

C. Sand and Dust. Exposure to windblown sand and dust particles.

D. Wind. Operation at wind velocities up to 250 miles per hour.

E. 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 unless otherwise indicated.

100-2.5 Salvage. All wastes such as removed asphalt, concrete, excess dirt, etc., shall become property of the Contractor and shall be legally disposed of offsite by the Contractor in compliance with all applicable environmental standards.

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. The Contractor shall assist the RPR 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 authority having jurisdiction.

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.

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 experience, until completion.

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 stated or shown otherwise and to the requirements of the National Electrical Code and its revisions as adopted by the local Agency Having Jurisdiction and shall be in accordance with

applicable Federal Aviation Administration's Advisory Circulars including amendments, the American National Standards Institute Standard C2.

Workmanship shall be consistent with the best commercial practices for installation of this type and in accordance with the highest standards of the electrical industry. All installations and adjustments shall be by competent electricians.

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 RPR as described above.

100-3.3 Site conditions. The horizontal and vertical locations of known underground utilities as shown or indicated by the Contract Documents are approximate and are based on information and data furnished by the Airport.

The Contractor shall have full responsibility for:

A. Reviewing and checking all information and data concerning utilities.

B. Locating all underground utilities shown or indicated in the Contract Documents which are affected by the Work.

C. Coordination of the Work with the owners of all utilities during construction.

D. Safety and protection of all utilities as provided in paragraph above.

E. Repair of any damage to utilities resulting from the Work in accordance with paragraphs above.

1. If Work is to be performed by any utility owner, the Contractor shall cooperate with such owners to facilitate the Work.

2. In the event of interruption to any utility service as a result of accidental breakage or as result of being exposed or unsupported, the Contractor shall promptly notify the utility owner and the RPR. If service is interrupted, repair work shall be continuous until the service is restored. No Work shall be undertaken around fire hydrants until provisions for continued service has been approved by the local fire authority.

At least five working days prior to commencing construction operations in an area which may involve underground utility facilities, the Contractor shall notify the RPR and the owners of confirmation of each underground utility facility shown or located but not identified on the drawings.

When excavating and trenching within the vicinity of existing cables or other utilities, the Contractor shall employ hand excavation to avoid damage. Any damage caused by the Contractor to such systems shall be repaired by the Contractor at his own expense and to the satisfaction of the RPR. It shall be the Contractor's responsibility to verify the exact locations of existing systems and utilities shown on the drawings. Additional utilities and systems not shown on the drawings may exist.

Utilities Not Shown or Indicated:

A. Prior to trenching verify that the trench route is free of metallic utilities by searching with a metal detector. Contractor shall provide the metal detector. Verify location of existing utilities through careful excavation or by impressing an identification signal (if acceptable to cable Owner) at an accessible location and following the path of the utility with a signal tracer.

B. If, while directly performing the Work, an underground utility is uncovered or revealed at the site which was not shown or indicated in the Contract Documents and which the Contractor could not reasonably have been expected to be aware of, the Contractor shall, promptly after becoming aware thereof and before performing any Work affected thereby (except in an emergency as

permitted by the Contract Documents) identify the owner of such underground utility and give written notice thereof to that owner and to the RPR. The RPR will promptly review the underground utility to determine the extent to which the Contract Documents and the Work should be modified to reflect the impacts of the discovered utility. The Contract Documents will be amended or supplemented to the extent necessary through the issuance of a change document by the RPR. During such time, the Contractor shall be responsible for the safety and protection of such underground utility as provided in the Contract Documents. The Contractor may be allowed an increase in the Contract Price or an extension of the Contract Time, or both, to the extent that they are directly attributable to the existence of any underground utility that was not shown or indicated in the Contract Documents and which the Contractor could not reasonably have been expected to be aware of.

Damaged Utilities: When utilities are damaged by the Contractor, the utility owner shall have the choice of repairing the utility or having the Contractor repair the utility. In the following circumstances, the Contractor shall reimburse the utility owner for repair costs or provide at no cost to the utility owner, all materials, equipment and labor necessary to complete repair of the damage:

A. When the utility is shown or indicated in the Contract Documents.

B. When the utility has been located by the utility owner.

C. When no locate was requested by the Contractor for utilities shown or indicated in the Contract Documents.

D. All visible utilities.

E. When the Contractor could have, otherwise, reasonably been expected to be aware of such utility.

100-3.4 Interruptions. Interruptions of runway lighting, taxiway lighting or signage circuits may be necessary during construction.

The Contractor shall provide a reliable shunt cable to provide temporary continuity of service to runway lights, taxiway lights or signs impacted during construction, where required.

The Contractor shall not interrupt any circuit or perform any work that might endanger any circuit until approval of the RPR has been received. Temporary cables shall be protected 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 drawings.

The Contractor shall remove all circuit cables from their respective power sources in the vault before working on the cables in the field. All such cables shall be so marked at the point of disconnection to prevent accidental reconnection. This work is incidental to the electrical work and no separate payment will be made.

METHOD OF MEASUREMENT

100-4.1 Measurement. No separate measurement shall be made for items in L-100, used to complete other items in these specifications.

BASIS OF PAYMENT

100-5.1 Payment. Payment for items in L-100 shall be included as incidental to pay items in subsequent L sections. These items shall include all incidentals as necessary to provide and place into operation a complete system.

END OF ITEM L-100

Item L-108 Underground Power Cable for Airports

DESCRIPTION

108-1.1 This item shall consist of furnishing and installing power cables that are direct buried and furnishing and/or installing power cables within conduit or duct banks per these specifications at the locations shown on the plans. It includes excavation and backfill of trench for direct-buried cables only. Also included are the installation of counterpoise wires, ground wires, ground rods and connections, cable splicing, cable marking, cable testing, and all incidentals necessary to place the cable in operating condition as a completed unit to the satisfaction of the RPR. This item shall not include the installation of duct banks or conduit, trenching and backfilling for duct banks or conduit, or furnishing or installation of cable for FAA owned/operated facilities.

EQUIPMENT AND MATERIALS

108-2.1 General.

a. Airport lighting equipment and materials covered by advisory circulars (AC) shall be approved under the Airport Lighting Equipment Certification Program per AC 150/5345-53, current version.

b. All other equipment and materials covered by other referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification, when requested by the RPR.

c. Manufacturer's certifications shall not relieve the Contractor of the responsibility to provide materials per these specifications. Materials supplied and/or installed that do not comply with these specifications shall be removed (when directed by the RPR) and replaced with materials that comply with these specifications at the Contractor's cost.

d. All materials and equipment used to construct this item shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment and delete any non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment to which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in the project that may accrue directly or indirectly from late submissions or resubmissions of submittals.

e. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications. The Contractor's submittals shall be electronically submitted in pdf format. The RPR reserves the right to reject any and all equipment, materials, or procedures that do not meet the system design and the standards and codes, specified in this document.

f. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for at least twelve (12) months from the date of final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner. The Contractor shall maintain a minimum insulation resistance in excess of 50 megohms, in accordance with Item L-130, with isolation transformers connected in new circuits and new segments of existing circuits through the end of the contract warranty

period when tested in accordance with AC 150/5340-26, *Maintenance Airport Visual Aid Facilities*, paragraph 5.1.3.1, Insulation Resistance Test.

108-2.2 Cable. Underground cable for airfield lighting facilities (runway and taxiway lights) shall conform to the requirements of AC 150/5345-7, Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits latest edition. Conductors for use on 6.6 ampere primary airfield lighting series circuits shall be single conductor, seven strand, #8 American wire gauge (AWG), L-824 Type C, 5,000 volts, non-shielded, with cross-linked polyethylene insulation (solid red or black), as shown on the drawings. All other conductors shall comply with FAA and National Electric Code (NEC) requirements. Conductor sizes noted above shall not apply to leads furnished by manufacturers on airfield lighting transformers and fixtures.

Wire for electrical circuits up to 600 volts shall comply with Specification L-824 and/or Commercial Item Description A-A-59544A and shall be type THWN-2, 75°C for installation in conduit and RHW-2, 75°C for direct burial installations. Conductors for parallel (voltage) circuits shall be type and size and installed in accordance with NFPA-70, National Electrical Code.

Unless noted otherwise, all 600-volt and less non-airfield lighting conductor sizes are based on a 75°C, THWN-2, 600-volt insulation, copper conductors, not more than three single insulated conductors, in raceway, in free air. The conduit/duct sizes are based on the use of THWN-2, 600-volt insulated conductors. The Contractor shall make the necessary increase in conduit/duct sizes for other types of wire insulation. In no case shall the conduit/duct size be reduced. The minimum power circuit wire size shall be #12 AWG.

Conductor sizes may have been adjusted due to voltage drop or other engineering considerations. Equipment provided by the Contractor shall be capable of accepting the quantity and sizes of conductors shown in the Contract Documents. All conductors, pigtails, cable step-down adapters, cable step-up adapters, terminal blocks and splicing materials necessary to complete the cable termination/splice shall be considered incidental to the respective pay items provided.

Cable type, size, number of conductors, strand and service voltage shall be as specified in the Contract Document.

108-2.3 Bare copper wire (guard wire, equipment ground and ground rods). Wire for guard wire installations for airfield lighting systems shall be No. 1/0 AWG bare stranded copper wire and for equipment ground conductor for airfield lighting systems shall be solid No. 6 AWG green-insulated per ASTM B3 and ASTM B8. For voltage powered circuits, the equipment grounding conductor shall comply with NEC Article 250.

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 long and 3/4 inch 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. A cast splice, employing a plastic mold and using epoxy resin equivalent to that manufactured by 3M™ Company, “Scotchcast” Kit No. 82-B, or an approved equivalent, used for potting the splice is acceptable.

b. The field-attached plug-in splice. Field attached plug-in splices shall be installed as shown on the plans. The Contractor shall determine the outside diameter of the cable to be spliced and furnish appropriately sized connector kits and/or adapters. Tape or heat shrink tubing with integral sealant shall be in accordance with the manufacturer’s requirements. Primary Connector Kits manufactured by Amerace, "Super Kit", Integro "Complete Kit", or approved equal is acceptable.

c. The factory-molded plug-in splice. Specification for L-823 Connectors, Factory-Molded to Individual Conductors, is acceptable.

d. The taped or heat-shrink splice. Taped splices employing field-applied rubber, or synthetic rubber tape covered with plastic tape is acceptable. The rubber tape should meet the requirements of ASTM D4388 and the plastic tape should comply with Military Specification MIL-I-24391 or Commercial Item Description A-A-55809.

Heat shrinkable tubing shall not be used.

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. 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 RPR proof of the qualifications of each proposed cable splicer for the airport cable type and voltage level to be worked on. Cable splicing/terminating personnel shall have a minimum of three (3) years continuous experience in terminating/splicing medium voltage cable.

108-2.6 Concrete. Concrete shall be proportioned, placed, and cured per Item P-610, Concrete for Miscellaneous Structures.

108-2.7 Flowable backfill. Flowable material used to backfill trenches for power cable trenches shall conform to the requirements of Item P-153, Controlled Low Strength Material.

108-2.8 Cable identification tags. Cable identification tags shall be made from a non-corrosive material with the circuit identification stamped or etched onto the tag. The tags shall be of the type as detailed on the plans.

108-2.9 Tape. Electrical tapes shall be Scotch™ Electrical Tapes –Scotch™ 88 (1-1/2 inch wide) and Scotch™ 23 linerless rubber splicing tape (2-inch wide), as manufactured by the Minnesota Mining and Manufacturing Company (3M™), or an approved equivalent.

108-2.10 Electrical coating. Electrical coating shall be Scotchkote™ as manufactured by 3M™, or an approved equivalent.

108-2.11 Existing circuits. Not applicable.

108-2.12 Detectable warning tape. Plastic, detectable, American Public Works Association (APWA) Red (electrical power lines, cables, conduit and lighting cable) with continuous legend tape shall be polyethylene film with a metalized foil core and shall be 3-6 inches wide. Detectable tape is incidental to the respective bid item. Detectable warning tape for communication cables shall be orange. Detectable warning tape color code shall comply with the APWA Uniform Color Code.

CONSTRUCTION METHODS

108-3.1 General. The Contractor shall install the specified cable at the approximate locations indicated on the plans. Unless otherwise shown on the plans, all cable required to cross under pavements expected to carry aircraft loads shall be installed in concrete encased duct banks. Cable shall be run without splices, from fixture to fixture.

Cable connections between lights will be permitted only at the light locations for connecting the underground cable to the primary leads of the individual isolation transformers. The Contractor shall be responsible for providing cable in continuous lengths for home runs or other long cable runs without connections unless otherwise authorized in writing by the RPR or shown on the plans.

In addition to connectors being installed at individual isolation transformers, L-823 cable connectors for maintenance and test points shall be installed at locations shown on the plans. Cable circuit identification markers shall be installed on both sides of the L-823 connectors installed and on both sides of slack loops where a future connector would be installed.

Provide not less than 3 feet of cable slack on each side of all connections, isolation transformers, light units, and at points where cable is connected to field equipment, and 20 feet of slack in handholes, looped and placed in saddle racks. Where provisions must be made for testing or for future above grade connections, provide enough slack to allow the cable to be extended at least one foot vertically above the top of the access structure. This requirement also applies where primary cable passes through empty light bases, junction boxes, and access structures to allow for future connections, or as designated by the RPR.

Primary airfield lighting cables installed shall have cable circuit identification markers attached on both sides of each L-823 connector and on each airport lighting cable entering or leaving cable access points, such as manholes, hand holes, pull boxes, junction boxes, etc. Markers shall be of sufficient length for imprinting the cable circuit identification legend on one line, using letters not less than 1/4 inch in size. The cable circuit identification shall match the circuits noted on the construction plans.

108-3.2 Installation in duct banks or conduits. This item includes the installation of the cable in duct banks or conduit per the following paragraphs. The maximum number and voltage ratings of cables installed in each single duct or conduit, and the current-carrying capacity of each cable shall be per the latest version of the National Electric Code, or the code of the local agency or authority having jurisdiction.

The Contractor shall make no connections or splices of any kind in cables installed in conduits or duct banks.

Unless otherwise designated in the plans, where ducts are in tiers, use the lowest ducts to receive the cable first, with spare ducts left in the upper levels. Check duct routes prior to construction to obtain assurance that the shortest routes are selected and that any potential interference is avoided.

Duct banks or conduits shall be installed as a separate item per Item L-110, Airport Underground Electrical Duct Banks and Conduit. The Contractor shall run a mandrel through duct banks or conduit prior to installation of cable to ensure that the duct bank or conduit is open, continuous and clear of debris. The mandrel size shall be compatible with the conduit size. The Contractor shall swab out all conduits/ducts and clean light bases, manholes, etc., interiors immediately prior to pulling cable. Once cleaned and swabbed, the light bases and all accessible points of entry to the duct/conduit system shall be kept closed except when installing cables. Cleaning of ducts, light bases, manholes, etc., is incidental to the pay item of the item being cleaned. All raceway systems left open, after initial cleaning, for any reason shall be re-cleaned at the Contractor’s expense. The Contractor shall verify existing ducts proposed for use in this project as clear and open. The Contractor shall notify the RPR of any blockage in the existing ducts.

The cable shall be installed in a manner that prevents harmful stretching of the conductor, damage to the insulation, or damage to the outer protective covering. The ends of all cables shall be sealed with moisture-seal tape providing moisture-tight mechanical protection with minimum bulk, or alternately, heat shrinkable tubing before pulling into the conduit and it shall be left sealed until connections are made. Where more than one cable is to be installed in a conduit, all cable shall be pulled in the conduit at the same time. The pulling of a cable through duct banks or conduits may be accomplished by hand winch or power winch with the use of cable grips or pulling eyes. Maximum pulling tensions shall not exceed

the cable manufacturer's recommendations. A non-hardening cable-pulling lubricant recommended for the type of cable being installed shall be used where required.

The Contractor shall submit the recommended pulling tension values to the RPR prior to any cable installation. If required by the RPR, pulling tension values for cable pulls shall be monitored by a dynamometer in the presence of the RPR. Cable pull tensions shall be recorded by the Contractor and reviewed by the RPR. Cables exceeding the maximum allowable pulling tension values shall be removed and replaced by the Contractor at the Contractor's expense.

The manufacturer's minimum bend radius or NEC requirements (whichever is more restrictive) shall apply. Cable installation, handling and storage shall be per manufacturer's recommendations. During cold weather, particular attention shall be paid to the manufacturer's minimum installation temperature. Cable shall not be installed when the temperature is at or below the manufacturer's minimum installation temperature. At the Contractor's option, the Contractor may submit a plan, for review by the RPR, for heated storage of the cable and maintenance of an acceptable cable temperature during installation when temperatures are below the manufacturer's minimum cable installation temperature.

Cable shall not be dragged across base can or manhole edges, pavement or earth. When cable must be coiled, lay cable out on a canvas tarp or use other appropriate means to prevent abrasion to the cable jacket.

108-3.3 Installation of direct-buried cable in trenches. Not used.

108-3.4 Cable markers for direct-buried cable. Not used.

108-3.5 Splicing. Connections of the type shown on the plans shall be made by experienced personnel regularly engaged in this type of work and shall be made as follows:

a. Cast splices. These shall be made by using crimp connectors for jointing conductors. Molds shall be assembled, and the compound shall be mixed and poured per the manufacturer's instructions and to the satisfaction of the RPR.

b. Field-attached plug-in splices. These shall be assembled per the manufacturer's instructions. These splices shall be made by plugging directly into mating connectors. The joint where the connectors come together shall be finished by one of the following methods: (1) wrapped with at least one layer of rubber or synthetic rubber tape and one layer of plastic tape, one-half lapped, extending at least 1-1/2 inches on each side of the joint (2) Covered with heat shrinkable tubing with integral sealant extending at least 1-1/2 inches on each side of the joint or (3) On connector kits equipped with water seal flap; roll-over water seal flap to sealing position on mating connector.

c. Factory-molded plug-in splices. These shall be made by plugging directly into mating connectors. The joint where the connectors come together shall be finished by one of the following methods: (1) Wrapped with at least one layer of rubber or synthetic rubber tape and one layer of plastic tape, one-half lapped, extending at least 1-1/2 inches on each side of the joint. (2) Covered with heat shrinkable tubing with integral sealant extending at least 1-1/2 inches on each side of the joint. or (3) On connector kits so equipped with water seal flap; roll-over water seal flap to sealing position on mating connector.

d. Taped or heat-shrink splices. Not used.

e. Assembly. Surfaces of equipment or conductors being terminated or connected shall be prepared in accordance with industry standard practice and manufacturer's recommendations. All surfaces to be connected shall be thoroughly cleaned to remove all dirt, grease, oxides, nonconductive films, or other foreign material. Paints and other nonconductive coatings shall be removed to expose base metal. Clean all surfaces at least 1/4 inch beyond all sides of the larger bonded area on all mating surfaces. Use a joint compound suitable for the materials used in the connection. Repair painted/coated surface to original condition after completing the connection.

108-3.6 Bare guard wire installation for lightning protection and grounding. If shown on the plans or included in the job specifications, bare copper guard wire shall be installed for lightning protection of the underground cables. The equipotential method has been applied, based upon sound engineering practice and lightning strike density.

a. Equipotential. The guard wire size is as shown on the plans. The equipotential method is applicable to all airfield lighting systems; i.e. runway, taxiway, apron – touchdown zone, centerline, edge, threshold and approach lighting systems. The equipotential method is also successfully applied to provide lightning protection for power, signal and communication systems. The light bases, counterpoise, etc – all components - are bonded together and bonded to the vault power system ground loop/electrode.

Guard wire shall be installed in the same trench for the entire length of buried cable, conduits and duct banks that are installed to contain airfield cables. The guard is centered over the cable/conduit/duct to be protected.

The guard wire conductor shall be installed no less than 8 inches minimum or 12 inches maximum above the raceway or cable to be protected, except as permitted below:

(1) The minimum guard wire conductor height above the raceway or cable to be protected shall be permitted to be adjusted subject to coordination with the airfield lighting and pavement designs.

(2) The guard wire conductor height above the protected raceway(s) or cable(s) shall be calculated to ensure that the raceway or cable is within a 45-degree area of protection, (45 degrees on each side of vertical creating a 90 degree angle).

The guard wire conductor shall be bonded to each metallic light base, mounting stake, and metallic airfield lighting component.

All metallic airfield lighting components in the field circuit on the output side of the constant current regulator (CCR) or other power source shall be bonded to the airfield lighting counterpoise system.

All components rise and fall at the same potential; with no potential difference, no damaging arcing and no damaging current flow.

See AC 150/5340-30, Design and Installation Details for Airport Visual Aids and NFPA 780, Standard for the Installation of Lightning Protection Systems, Chapter 11, for a detailed description of the Equipotential Method of lightning protection.

Reference FAA STD-019G, Lightning and Surge Protection, Grounding Bonding and Shielding Requirements for Facilities and Electronic Equipment, Part 4.1.1.7.

Grounding electrodes may be rods, ground dissipation plates, radials, or other electrodes listed in the NFPA 70 (NEC) or NFPA 780.

Where raceway is installed by the directional bore, jack and bore, or other drilling method, the guard wire conductor is not necessary and conduit type shall be Gila-Duct armored conduit, as shown on the plans.

The guard wire shall also be exothermically welded to ground rods installed as shown on the plans but not more than 500 feet apart around the entire circuit. The guard wire system shall be continuous and terminate at the transformer vault or at the power source. It shall be securely attached to the vault or equipment external ground ring or other made electrode-grounding system. The connections shall be made as shown on the plans and in the specifications.

Where an existing airfield lighting system is being extended or modified, the new guard wire conductors shall be interconnected to existing counterpoise conductors at each intersection of the new and existing airfield lighting guard wire/counterpoise systems.

b. Parallel Voltage Systems. Provide grounding and bonding in accordance with NFPA 70, National Electrical Code.

108-3.7 Guard wire installation above multiple conduits and duct banks. Guard wire 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 guard wire wires above the conduits shall be adequate to provide a complete area of protection measured 45 degrees each side of vertical.

Where duct banks pass under pavement to be constructed in the project, the guard wire shall be placed above the duct bank. Reference details on the construction plans.

108-3.8 Guard wire installation at existing duct banks. When airfield lighting cables are indicated on the plans to be routed through existing duct banks, the new guard wire 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 guard wire conductor shall be bonded to the existing counterpoise system.

108-3.9 Exothermic bonding. Bonding of guard wire shall be by the exothermic welding process or equivalent method accepted by the RPR. Only personnel experienced in and regularly engaged in this type of work shall make these connections.

Contractor shall demonstrate to the satisfaction of the RPR, the welding kits, materials and procedures to be used for welded connections prior to any installations in the field. The installations shall comply with the manufacturer's recommendations and the following:

a. All slag shall be removed from welds.

b. Using an exothermic weld to bond the guard wire to a lug on a galvanized light base is not recommended unless the base has been specially modified. Consult the manufacturer's installation directions for proper methods of bonding copper wire to the light base. See AC 150/5340-30 for galvanized light base exception.

c. If called for in the plans, all buried copper and weld material at weld connections shall be thoroughly coated with 6 mm of 3M™ Scotchkote™, or approved equivalent, or coated with coal tar Bitumastic® material to prevent surface exposure to corrosive soil or moisture.

108-3.10 Testing. The Contractor shall furnish all necessary equipment and appliances for testing the airport electrical systems and underground cable circuits before and after installation. The Contractor shall perform all tests in the presence of the RPR. All texting and sequencing of tests shall be in accordance with Specification Item L-130.

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 installed and ground rods, grounding connectors, and trench marking tape ready for operation, and accepted as satisfactory. Separate measurement shall be made for each cable or guard wire wire installed in trench, duct bank or conduit. The measurement for this item shall not include additional quantities required for slack.

BASIS OF PAYMENT

108-5.1 Payment will be made at the contract unit price for trenching, bare guard wire installed in trench (direct-buried), or cable and equipment ground installed in duct bank or conduit, in place by the Contractor and accepted by the RPR. This price shall be full compensation for furnishing all materials and for all preparation and installation of these materials, and for all labor, equipment, tools, and incidentals, including ground rods and ground connectors, trench marking tape and any additional field splices, necessary to complete this item.

Payment will be made under:

Item L-108-5.1	No. 8 L-824C Cable, Solid Black Insulation - per linear foot
Item L 108 5.2	No. 8 L-824C Cable, Solid Red Insulation - per linear foot
Item L-108-5.3	No. 1/0 AWG Bare Copper Guard Wire - per linear foot
Item L-108-5.4	Solid No. 6 AWG Insulated Equipment Ground Conductor – per linear foot

REFERENCES

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

Advisory Circulars (AC)

AC 150/5340-26	Maintenance of Airport Visual Aid Facilities
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors
AC 150/5345-53	Airport Lighting Equipment Certification Program

Commercial Item Description

A-A-59544A	Cable and Wire, Electrical (Power, Fixed Installation)
A-A-55809	Insulation Tape, Electrical, Pressure-Sensitive Adhesive, Plastic

ASTM International (ASTM)

ASTM B3	Standard Specification for Soft or Annealed Copper Wire
ASTM B8	Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM B33	Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes
ASTM D4388	Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes

Mil Spec

MIL-PRF-23586F	Performance Specification: Sealing Compound (with Accelerator), Silicone Rubber, Electrical

MIL-I-24391	Insulation Tape, Electrical, Plastic, Pressure Sensitive

National Fire Protection Association (NFPA)

NFPA-70	National Electrical Code (NEC)
NFPA-780	Standard for the Installation of Lightning Protection Systems

American National Standards Institute (ANSI)/Institute of Electrical and Electronics Engineers (IEEE)

ANSI/IEEE STD 81	IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System

Federal Aviation Administration Standard

FAA STD-019G	Lightning and Surge Protection, Grounding Bonding and Shielding Requirements for Facilities and Electronic Equipment

END OF ITEM L-108

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Item L-109 Fiber Optic Cable and Hardware

DESCRIPTION

109-1.1 This section includes the furnishing and installation of optical fiber cable and associated hardware in accordance with and at the locations shown on the plans. The Work shall include the installation of cable in conduit, terminations, cable marking, and testing of the cable, and all incidentals necessary to place the cable in operation condition as a completed unit.

The section shall also consist of intercepting existing fiber optic cables and routing cables as shown on the plans.

109-1.2 References.

A. Comply with National Electrical Code for components and installation.

B. All cables shall be UL listed for application and service indicated in the Contract Documents.

109-1.3 Submittals.

A. Submit the following:

1. Product data for fiber optic cable, break-out kits, connectors, and terminations.
2. Fiber optic cable installation plan. Plan shall indicate setup points including intermediate pull points, methods for handling slack, methods of storing cable during off shift times, etc. pulling tension calculations shall be produced. Information to demonstrate the capabilities and experience of the installer / testing agency. Include list of completed projects with project names, addresses, names of RPRs and Owners, and other information specified.
3. OTDR traces indicating and interpreting test results including date and time the test was performed. Current calibration data for any equipment used shall be included.
4. Test data shall be entered into a project specific Excel spreadsheet, provided by the RPR, which will consist of testing points, span losses, connector losses, etc.

109-1.4 Quality assurance. The Contractor shall engage a certified installer with a minimum 5 years experience in installing optical fiber cables.

All cable of each cable type shall be the product of a single manufacturer.

MATERIALS

109-2.1 Manufacturers. Manufacturers of fiber optical cable and components that may be incorporated in the Work include, but are not limited to, the following:

A. Corning Corp.

B. Prysmian (Cable P/N FAACD-12-HB-024-E3)

109-2.2 Optical fiber cables and connectors. Cables shall be factory-fabricated, low-loss, glass-type, loose tube, optical fiber cables. Single-Mode graded-index outdoor/duct Type B, 24 fibers.

A. Cladding Diameter: 125.0 ± 1.0 µm. (non circularity of cladding must not exceed 1.0%)

B. Core-to-Cladding Offset: ≤ 0.8 µm.

C. Coating Diameter: 125 ± 10 µm.

D. Colored Finer Diameter: nominal 250 µm.

E. Attenuation Uniformity: no point discontinuity greater than 0.10 dB at either 1310 nm or 1550 nm.

F. Cutoff Wavelength: the cabled fiber cutoff wavelength shall be < 1260 nm.

G. Mode-Field Diameter: 8.8 to 9.3 µm as determined by either FOTP 164A or 167A

H. The coating shall be dual layered, UV-cured acrylate applied by the fiber manufacturer and mechanically strippable.

I. Fiber Grade: The attenuation of each individual fiber shall not exceed 0.5 dB/km at 1310 nm and 0.3 dB/km at 1550 nm.

J. Ratings: Maximum dispersion shall be ≤ 3.2 ps/(nm*km) from 1285 nm to 1330 nm and shall be < 18ps/(nm*km) at 1550 nm.

K. Operating Temperature Range: Minus 40 to 75 degrees C.

L. Requirements: The fiber manufacturer shall proof-test 100% of the optical fiber to a minimum load of 0.69 GN/m2.

M. Optical fibers shall be placed inside a loose buffer tube. Each buffer tube shall contain 1 to 12 fibers and the fibers shall not adhere to the inside of the buffer tube.

N. Each fiber shall be distinguishable by means of color coding that meets TIA/EIA-598-A, “Optical Fiber Cable Coding”.

O. Buffer tubes containing the fibers shall be distinguishable by means of color coding that meets TIA/EIA-598-A, “Optical Fiber Cable Coding”. Color coding shall be as follows:

1. Blue	5. Slate	9. Yellow
2. Orange	6. White	10. Violet
3. Green	7. Red	11. Rose
4. Brown	8. Black	12. Aqua

In buffer tubes containing the fibers, the colors shall be stable across the storage and operating temperature range and shall not be subject to fading or smearing onto each other. Colors shall not cause fibers to stick together.

Each buffer tube shall be dry and gel-free. The tube shall be free from dirt and foreign matter.

The buffer tubes shall be stranded around a central member using the reverse oscillation, or S-Z, stranding process. The central member shall consist of a glass reinforced plastic rod to prevent buckling of the cable.

The cable core shall contain water blocking material. The water blocking material shall be non-nutritive to fungus, electrically non-conductive and homogenous. It shall also be free from dirt and foreign matter and shall be readily removable with conventional nontoxic solvents.

Binders shall be applied with sufficient tension to secure the buffer tubes to the central member without crushing the buffer tubes. The binders shall be non-hygroscopic, non-wicking and dielectric with low shrinkage.

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

Tensile strength shall be provided by a combination of high tensile strength dielectric yarns that

shall be stranded evenly around the cable core and shall not be less than 0.69 GN/m2.

Fiber optic cable for installation in field duct banks shall have an inner jacket that is continuous extruded polyethylene free of voids or inclusions. The inner jacket thickness at any point shall not be less than 0.4 millimeters. The inner jacket material shall be applied directly over the tensile strength members and water blocking material. The polyethylene shall contain materials to prevent the growth of fungus. Fiber optic cable shall also have an outer jacket that shall be continuous extruded nylon or polyvinylidene fluoride (PVDF) free of voids or inclusions that is impervious to hydro-carbons and provides ultraviolet light protection. The outer jacket shall have a nominal thickness of 1.15 millimeters (the average of thickness shall not be less than 1.00 millimeters, not greater than 1.30 millimeters and no spot shall be less than 0.80 millimeters thick). The outer jacket shall be smooth and free from holes, splits, blisters, or other surface flaws. The eccentricity of the finished cable including both the inner and outer jacket shall not exceed 40%. The carbon black contents for inner and outer jackets shall be 2.6 +/- 0.25% by weight to provide aging characteristics consistent with a 40-year cable life.

The cable jacket shall be marked every meter with manufacturer's name, sequential meter markings, and year of manufacturer. The actual length of the cable shall be within ± 1% of the length markings. The markings shall be in contrasting color to the cable jacket. The height of the marking shall be approximately 2.5 mm.

P. Optical Fiber Connectors: Precision SC-compatible connectors shall be used for all fiber optic cable. Connector shall be epoxy or hot melt composed of polymeric or stainless steel body, ceramic or stainless ferrule, and PVC bend relief boot. Maximum loss shall be 0.25dB. Durability shall be <0.2dB change after 5000 mating cycles.

Q. Optical Fiber Splices: None allowed, except where specifically shown on Contract Documents.

R. Fiber Count: As identified on Contract Documents.

S. Breakout Kits: Breakout kits shall be designed to integrate with the fiber optic cable and shall include PVC tubing to protect the individual fibers. Breakout kits shall provide positive strain relief between the fiber optic cable and the connector.

T. Patch Panels: The fiber optic patch panels, installed as a demarc at the base of the tower, shall be Corning–Landscape model WCH-04P or equal. Fiber optic patch panel shall consist of four 12 fiber panels with SC connectors. The fiber optic patch panel will be furnished and installed by the Federal Aviation Administration (FAA), as indicated on the contract plans.

U. Innerduct: All fiber optic cable installed in field duct banks shall also be installed in 1" general purpose innerduct installed in the specified duct prior to installation of the fiber optic cable.

V. Tracer Wire: Fiber optic runs should include #10 THWN stranded yellow tracer wire for locating purposes and connected in its entirety as a continuous conductor.

109-2.3 Quality assurance. The basis of sampling and testing for quality control shall comply with the provisions of FAA standard FAA-E-2761c Section 4.

CONSTRUCTION METHODS

109-3.1 Examination. Examine raceways and other elements to receive cable for compliance with installation tolerances and other adverse conditions. Do not proceed with installation until unsatisfactory conditions have been corrected.

109-3.2 Installation. Install cables for communication and for control and monitoring, as shown on the Contract Documents, according to manufacturer's written instructions.

Install transmission media without damaging conductors, shield, or jacket. Do not bend cable, in handling or installation, to smaller radii than minimum recommended by manufacturer. Pull cables without exceeding cable manufacturer's recommended pulling tensions. Pull cables simultaneously where more than one is being installed in same raceway or conduit. Use pulling compound or lubricant compound that shall not deteriorate conductor or insulation. Use pulling means, including rope and basket weave wire/cable grips that shall not damage media or raceway. All cable shall be installed in raceway. Place 20 feet of slack in handholes, looped and placed in saddle racks.

Use connectors that are compatible with cable material. Connectors shall be installed in accordance with the manufacturer's recommended installation practices.

No single pull shall have more than 180 degrees combined change of direction. Where it is not possible to pull cables continuously within this parameter, the Contractor shall employ back feeding and center-pulling techniques. When using these techniques, the "figure-eight" configuration shall be used to prevent kinks or twisting when the cable is unrolled or backfed.

The ends of all cable shall be sealed with a moisture-seal tape before pulling into conduit or innerduct. It shall be left sealed until terminations or connections are made. All fibers shall be labeled as described in the Contract Documents.

FIELD TESTING

The Contractor shall perform such on the reel tests as he feels necessary to assure that the material is acceptable prior to installation. These tests shall have no bearing on final acceptance and shall be performed solely for the Contractor’s benefit.

All other tests shall be performed after installation and termination.

Allowable Losses: The allowable losses for attenuation shall be as contained in Section 109-2.2 and summarized here:

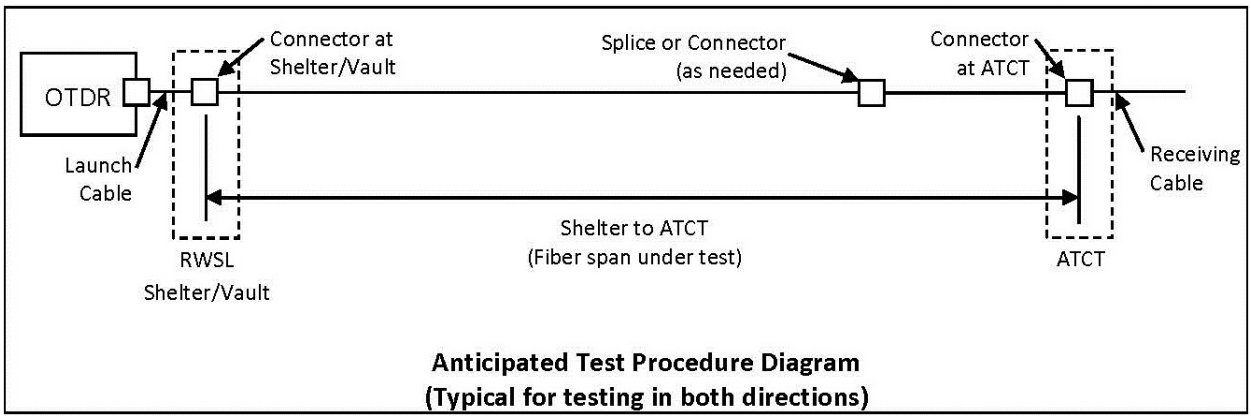
Span (fiber) losses – 0.5dB/km @ 1310nm and 0.3dB/km @ 1550nm
Connector losses – 0.5 dB / pair of connectors

Certify compliance with test parameters and manufacturer’s recommendations.

Each fiber shall be tested for end-to-end attenuation in both directions and shall be checked with an Optical Time Domain Reflectometer (OTDR). All fibers shall be tested and test results shall be documented in report form to the RPR, per Paragraph 109-1.3. Any component of the link which does not meet minimum specified levels shall be brought to the attention of the RPR.

Prior to testing, ensure that test jumpers are of the same fiber core size and connector type as the cable system. Set all equipment to the same wavelength. Ensure that all connectors, sleeves and jumpers are properly cleaned.

Perform end-to-end attenuation testing in accordance with EIA/TIA-526-7, Method B, "Optical Power Loss Measurements of Installed Singlemode Fiber Cable Plant." This testing method shall be amended such that attenuation is captured for connectors at both ends during tests in both directions by utilizing an appropriate patch cord on the receiving end. Launch and receiving cables shall have a length of more than 100’ and less than 330’. See diagram below for example testing configuration.



Anticipated Test Procedure Diagram
(Typical for testing in both directions)

Provide printed and electronic copies of OTDR traces (including source program if necessary to read), and documentation of all testing in report form to the RPR for review. Include wavelengths, fiber type, fiber identification, measurement direction, test equipment model and serial numbers, date, reference setup and operators.

Perform continuity test, cable length measurement and detect fiber fractures or other defects through analysis of the backscattering signal with an Optical Time Domain Reflectometer.

Perform attenuation measurement of the cable loss with a single mode optical test set.

Perform attenuation measurement to include the losses of each splice and connector.

Perform tests on all new fibers between all patch panels or splices where connectors are used. In addition, perform tests on all fibers comprising the overall communications path, including any intermediate patch panels, splices and/or existing fiber optic cable, between the shelter patch panel and the ATCT demarcation box. Test data shall be summarized on the RPR provided electronic spreadsheet. A sample of the spreadsheet is attached.

METHOD OF MEASUREMENT

109-4.1 Measurement. Measurement for installation of single mode fiber optic cable will be made at the contract unit price per linear foot installed in place by the Contractor and accepted by the RPR. No separate measurement will be made for the patch panel installations (furnished by others), innerduct, tracer wire, connectors, breakout kits, labeling, termination, and testing of the fiber optic cable required for the field installation, as they will be considered incidental.

BASIS OF PAYMENT

109-5.1 Payment. Payment for the furnishing and installation of single mode fiber optic cable will be made at the contract unit price per linear foot installed in place by the Contractor and accepted by the RPR. This price shall be full compensation for furnishing all labor, equipment, tools, materials, and incidentals including but not limited to patch panel installation (furnished by others), innerducts, tracer wire, connectors, breakout kits, termination, labeling, and testing necessary to complete this item.

Payment will be made under:

Item L-109-5.1 Single Mode Fiber Optic Cable (24 fibers) – per linear foot

REFERENCE DOCUMENTS

ANSI/TIA/EIA-568-B.3	Optical Fiber Cabling Components Standard
FAA-E-2761c	Cable, Fiber Optic, Multimode and Single-Mode, Multifiber

Sample Test Summary and Directions

Fiber Optic Test Data Input Directions

General Info Tab

Input the following in column B

- Three letter airport designator
- Test date
- Fiber manufacturer
- Fiber product name
- No. of fibers if not 24
- Connector brand
- Test location A (Usually Shelter #x or ATCT)
- Test location B (Usually Shelter #x or ATCT)
- Testing performers
- Test equipment manufacturer
- Test equipment model
- Test equipment serial number
- Test equipment calibration date

Cable Attenuation Tab

For each fiber input the following:

- In column C, input span loss from A to B in (db)
- In column D, input span loss from B to A in (db)
- In column F, input the fiber length in (km)

Spreadsheet will calculate actual span loss and determine pass/fail.

Connector Attenuation Tab

For each fiber input the following:

- In column C, input the A connector loss as measured in the A to B direction
- In column D, input the B connector loss as measured in the A to B direction
- In column E, input the A connector loss as measured in the B to A direction
- In column F, input the B connector loss as measured in the B to A direction

Spreadsheet will calculate the average connector loss for each connector and determine pass/fail.

Fiber Optic Cable Testing Summary

General Information

RWSL Site:
Date:
Fiber Type:
Fiber Manufacturer:
Fiber Product Name:
No. of Fibers:
Connector Brand:
Connector Type:
Test Location A:
Test Location B:
Test Performed By:

Allowable Span Loss @ 1310 nm:
Allowable Span Loss @ 1550 nm:
Allowable Connector Loss:

Test Equipment Manufacturer:
Test Equipment Model:
Test Equipment Serial Number:
Equipment Calibration Date:

HNTB

Fiber Optic Cable Testing Summary

Cable Attenuation

RWSL Site: XXX
Date: x/xx/xxxx

Fiber ID	Wavelength (nm)	Distance (km)	Span Loss		Avg. Span Loss (dB)	Actual Span Loss (dB/km)	Allowable Span Loss (dB/km)	Pass/Fail
			A→B (dB)	B→A (dB)				
1	1310						0.5	
1	1550						0.3	
2	1310						0.5	
2	1550						0.3	
3	1310						0.5	
3	1550						0.3	
4	1310						0.5	
4	1550						0.3	
5	1310						0.5	
5	1550						0.3	
6	1310						0.5	
6	1550						0.3	
7	1310						0.5	
7	1550						0.3	
8	1310						0.5	
8	1550						0.3	
9	1310						0.5	
9	1550						0.3	
10	1310						0.5	
10	1550						0.3	
11	1310						0.5	
11	1550						0.3	
12	1310						0.5	
12	1550						0.3	
13	1310						0.5	
13	1550						0.3	
14	1310						0.5	
14	1550						0.3	
15	1310						0.5	
15	1550						0.3	
16	1310						0.5	
16	1550						0.3	
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.
24	1310						0.5	
24	1550						0.3	

HNTB

Fiber Optic Cable Testing Summary

Connector Attenuation

RWSL Site: XXX
Date: x/xx/xxxx

Fiber ID	Wavelength (nM)	Connect or Loss A→ B		Connect or Loss B→ A		Avg. A Connector Loss (dB)	Avg. B Connector Loss (dB)	Allowable Connector Loss (dB)	A Pass / Fail	B Pass / Fail
		A (dB)	B (dB)	A (dB)	B (dB)					
1	1310					0	0	0.5		
1	1550					0	0	0.5		
2	1310					0	0	0.5		
2	1550					0	0	0.5		
3	1310					0	0	0.5		
3	1550					0	0	0.5		
4	1310					0	0	0.5		
4	1550					0	0	0.5		
5	1310					0	0	0.5		
5	1550					0	0	0.5		
6	1310					0	0	0.5		
6	1550					0	0	0.5		
7	1310					0	0	0.5		
7	1550					0	0	0.5		
8	1310					0	0	0.5		
8	1550					0	0	0.5		
9	1310					0	0	0.5		
9	1550					0	0	0.5		
10	1310					0	0	0.5		
10	1550					0	0	0.5		
11	1310					0	0	0.5		
11	1550					0	0	0.5		
12	1310					0	0	0.5		
12	1550					0	0	0.5		
13	1310					0	0	0.5		
13	1550					0	0	0.5		
14	1310					0	0	0.5		
14	1550					0	0	0.5		
15	1310					0	0	0.5		
15	1550					0	0	0.5		
16	1310					0	0	0.5		
16	1550					0	0	0.5		
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
24	1310					0	0	0.5		
24	1550					0	0	0.5		

END OF ITEM L-109

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Item L-110 Airport Underground Electrical Duct Banks and Conduits

DESCRIPTION

110-1.1 This item shall consist of underground electrical conduits and duct banks (single or multiple conduits encased in concrete or buried in sand) installed per this specification at the locations and per the dimensions, designs, and details shown on the plans. This item shall include furnishing and installing of all underground electrical duct banks and individual and multiple underground conduits and removal of existing duct banks. It shall also include all turfing trenching, backfilling, removal, and restoration of any paved or turfed areas; handholes, 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. Verification of existing ducts is incidental to the pay items provided in this specification.

EQUIPMENT AND MATERIALS

110-2.1 General.

A. All equipment and materials covered by referenced specifications shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when requested by the RPR.

B. Manufacturer's certifications shall not relieve the Contractor of the responsibility to provide materials per these specifications and acceptable to the RPR. Materials supplied and/or installed that do not comply with these specifications shall be removed, when directed by the RPR and replaced with materials, that comply with these specifications, at the Contractor's cost.

C. All materials and equipment used to construct this item shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify products or models applicable to this project. Indicate all optional equipment and delete non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment for which they apply on each submittal sheet. Markings shall be made bold and clear with arrows or circles (highlighting is not acceptable). The Contractor is solely responsible for delays in project that accrue directly or indirectly from late submissions or resubmissions of submittals.

D. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications. The Contractor's submittals shall be electronically submitted in pdf format, tabbed by specification section. The RPR reserves the right to reject any and all equipment, materials or procedures that do not meet the system design and the standards and codes specified in this document.

E. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of at least twelve (12) months from final acceptance by the Owner. The defective materials and/or equipment shall be repaired or replaced, at the Owner's discretion, with no additional cost to the Owner.

110-2.2 Steel conduit. Rigid galvanized steel (RGS) conduit and fittings shall be hot dipped galvanized inside and out and conform to the requirements of Underwriters Laboratories Standards 6, 514B, and 1242. All RGS conduits or RGS elbows installed below grade, in concrete, permanently wet locations or

other similar environments shall be painted with a 10-mil thick coat of asphaltum sealer or shall have a factory-bonded polyvinyl chloride (PVC) cover. Any exposed galvanizing or steel shall be coated with 10 mils of asphaltum sealer. When using PVC coated RGS conduit, care shall be exercised not to damage the factory PVC coating. Damaged PVC coating shall be repaired per the manufacturer's written instructions. In lieu of PVC coated RGS, corrosion wrap tape shall be permitted to be used where RGS is in contact with direct earth.

110-2.3 Plastic conduit. Plastic conduit and fittings-shall conform to the following requirements:

- UL 514B covers W-C-1094-Conduit fittings all types, classes 1 thru 3 and 6 thru 10.
- UL 514C covers W-C-1094- all types, Class 5 junction box and cover in plastic (PVC).
- UL 651 covers W-C-1094-Rigid PVC Conduit, types I and II, Class 4.
- UL 651A covers W-C-1094-Rigid PVC Conduit and high-density polyethylene (HDPE) Conduit type III and Class 4.

Underwriters Laboratories Standards UL-651 and Article 352 of the current National Electrical Code shall be one of the following, as shown on the plans:

A. Type I–Schedule 40 and Schedule 80 PVC suitable for underground use either direct-buried or encased in concrete.

B. Type II–Schedule 40 PVC suitable for either above ground or underground use.

C. Type III – Schedule 80 PVC suitable for either above ground or underground use either direct-buried or encased in concrete.

D. Type III –HDPE pipe, minimum standard dimensional ratio (SDR) 11, suitable for placement with directional boring under pavement.

The type of solvent cement shall be as recommended by the conduit/fitting manufacturer.

110-2.4 Split conduit. Not used.

110-2.5 Liquidtight flexible steel conduit. Liquidtight flexible steel conduit shall conform to Federal Spec. A-A-55810. Liquidtight flexible steel conduit shall be limited to a maximum length of 6 ft., as permitted by the NEC.

110-2.6 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.

110-2.7 Concrete. Concrete shall be proportioned, placed, and cured per Item P-610, Concrete for Miscellaneous Structures, or Item P-611, Quick Setting, High Early Strength Structural Concrete, as shown on the plans.

110-2.8 Handholes and electrical vaults. Handholes and electrical vaults shall be rated as specified (either aircraft or H20), suitable for use adjacent to airfield taxiways and runways. Precast concrete handholes and electrical vaults, covers, tops, and related assemblies shall conform to ASTM C 478 and shall be furnished by a plant meeting National Precast Concrete Association Plant Certification Program or another RPR-approved third party certification program.

Concrete for handholes and electrical vaults shall be 7,000 psi. Precast units shall be the product of a manufacturer regularly engaged in the manufacture of precast concrete handholes and electrical vaults. Top, walls, and bottom shall consist of reinforced concrete. Walls and bottom shall be of monolithic concrete construction. Covers shall fit frames without undue play. Steel and iron shall be formed to shape with sharp

lines and angles. Castings shall be free from warp and blow holes that may impair their strength or appearance. Exposed metal shall have a smooth finish and sharp lines. Provide all necessary lugs and brackets. Door cover section shall be provided with pre-manufactured or welded grounding strap lug, braided electrical grounding strap, locking latch, and appropriately engraved/inscribed identification on top of cover for the intended application. The text "FAA RWSL ##", where "##" is the respective handhole identification, as indicated on the plans, shall be cast or stamped in the top face of all handhole covers. Cable racks, including rack arms and insulators, shall be adequate to accommodate the cable. Cable racks, rack arms, and support brackets shall be fiberglass, PVC, or nylon, and shall be rated for 350-pound load, minimum. Support hardware such as screws, nuts, bolts, and anchors shall be 316 Stainless Steel with field applied PVC coating. Handholes and electrical vaults shall have a sump, ground rod knockouts, raceway knockouts, and cast in place galvanized channels for securing cable racks.

All handholes and electrical vaults shall be provided with a saddle rack on each vertical wall surface where cables are routed. Saddle racks shall be the single-saddle type with 3" saddle throat opening and slip-on lock assembly. Saddle racks shall be constructed of high performance polymer with UV stabilization. Where installed in petroleum or chemical environments, saddle racks shall be constructed of super tough yellow nylon with UV stabilization. Mounting shall be per manufacturer's requirements for "permanent installation". Saddle racks shall be manufactured by Underground Devices Inc., or approved equal.

110-2.9 Duct markers. The location of direct buried conduit on the airfield shall be marked by a concrete slab marker 2 ft square and 4 inches thick extending approximately 1 inch above the surface.

The markers shall be located above the ends of all ducts or duct banks, except where ducts terminate in a handholes, manhole, or building. Where duct banks terminate, provide a duct marker labeled, "DUCT ENDS". The Contractor shall impress the appropriate word, such as "DUCT" or "CONDUIT" on each marker slab. He shall also impress on the slab the number and size of conduit or ducts beneath the marker. The letters shall be 3 inches high and 2 inches wide with width of stroke 1/2 inch and 1/4 inch deep or as large as the available space permits.

Each conduit run shall also be marked at approximately every 200 feet along the conduit run, with an additional marker at each change of direction of conduit run. All other conduit buried directly in the earth shall be marked in the same manner. Markers shall be installed immediately above the conduit. The Contractor shall impress the word "conduit" and directional arrows on each conduit marking slab.

110-2.10 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.

110-2.11 Detectable warning tape. Plastic, detectable, American Public Works Association (APWA) red (electrical power lines, cables, conduit and lighting cable), orange (telephone/fiber optic cabling) with continuous legend magnetic tape shall be polyethylene film with a metallized foil core and shall be 3-6 inches wide. Detectable tape is incidental to the respective bid item.

CONSTRUCTION METHODS

110-3.1 General. The Contractor shall install underground duct banks and conduits at the approximate locations indicated on the plans. The RPR shall indicate specific locations as the work progresses, if required to differ from the plans. Duct banks and conduits shall be of the size, material, and type indicated on the plans or specifications. Where no size is indicated on the plans or in the specifications, conduits shall be not less than 2 inches 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 per 100 feet. 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. The top of the duct bank shall not be less than 36 inches below finished grade.

The Contractor shall mandrel each individual conduit whether the conduit is direct-buried or part of a duct bank. An iron-shod mandrel, not more than 1/4 inch smaller than the bore of the conduit shall be pulled or pushed through each conduit. The mandrel shall have a leather or rubber gasket slightly larger than the conduit hole.

The Contractor shall swab out all conduits/ducts and clean base can, manhole, pull boxes, etc., interiors immediately prior to pulling cable. Once cleaned and swabbed the light bases, manholes, pull boxes, etc., and all accessible points of entry to the duct/conduit system shall be kept closed except when installing cables. Cleaning of ducts, base cans, manholes, etc., is incidental to the pay item of the item being cleaned. All raceway systems left open, after initial cleaning, for any reason shall be recleaned at the Contractor's expense. All accessible points shall be kept closed when not installing cable. The Contractor shall verify existing ducts proposed for use in this project as clear and open. The Contractor shall notify the RPR of any blockage in the existing ducts.

For pulling the permanent wiring, each individual conduit, whether the conduit is direct-buried or part of a duct bank, shall be provided with a 200-pound 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.

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 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 sieve. Flowable backfill may alternatively be used

Underground electrical warning (Caution) tape shall be installed in the trench above all underground duct banks and conduits in unpaved areas. Contractor shall submit a sample of the proposed warning tape for approval by the RPR. If not shown on the plans, the warning tape shall be located minimum 6 inches above the duct/conduit or the guard 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.

Changes in direction of runs exceeding 10 degrees, either vertical or horizontal, shall be accomplished using manufactured sweep bends.

Whether or not specifically indicated on the drawings, where the soil encountered at established duct bank grade is an unsuitable material, as determined by the RPR, the unsuitable material shall be removed per Item P-152 and replaced with suitable material. Additional duct bank supports shall be installed, as approved by the RPR.

All excavation shall be unclassified and shall be considered incidental to Item L-110. Dewatering necessary for duct installation, and erosion per federal, state, and local requirements is incidental to Item L-110.

Unless otherwise specified, excavated materials that are deemed by the RPR to be unsuitable for use in backfill or embankments shall be removed and disposed of offsite.

Any excess excavation shall be filled with suitable material approved by the RPR and compacted per Item P-152.

It is the Contractor's responsibility to locate existing utilities within the work area prior to excavation. Where existing active cables) cross proposed installations, the Contractor shall ensure that these cables are adequately protected. Where crossings are unavoidable, no splices will be allowed in the existing cables, except as specified on the plans. Installation of new cable where such crossings must occur shall proceed as follows:

A. Existing cables shall be located manually. Unearthed cables shall be inspected to assure absolutely no damage has occurred

B. Trenching, etc., in cable areas shall then proceed with approval of the RPR, with care taken to minimize possible damage or disruption of existing cable, including careful backfilling in area of cable.

In the event that any previously identified cable is damaged during the course of construction, the Contractor shall be responsible for the complete repair.

110-3.2 Duct banks. Unless otherwise shown in the plans, duct banks shall be installed so that the top of the concrete envelope is not less than 36 inches below finished grade where installed in unpaved areas. Duct bank continuation under existing airfield pavements shall utilize high-density polyethylene (HDPE) conduit per Item L-108 to prevent disturbance of existing pavement.

Unless otherwise shown on the plans, duct banks under paved areas shall extend at least 3 feet beyond the edges of the pavement or 3 feet 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 thick prior to its initial set. The Contractor shall space the conduits not less than 3 inches 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 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 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 intervals. Spacers shall be in the proper sizes and configurations to fit the conduits. Locking collars and spacers shall be submitted to the RPR for review prior to use.

When specified, the Contractor shall reinforce the bottom side and top of encasements with steel reinforcing mesh or fabric or other approved metal reinforcement. When directed, the Contractor shall supply additional supports where the ground is soft and boggy, where ducts cross under roadways, or where shown on the plans. Under such conditions, the complete duct structure shall be supported on reinforced concrete footings, piers, or piles located at approximately 5-foot 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, 3-6 inches wide tape, 8 inches minimum below grade above all underground conduit or duct lines not installed under pavement. Utilize the 3-inch wide tape only for single conduit runs. Utilize the 6-inch wide tape for multiple conduits and duct banks. For duct banks equal to or greater than 24 inches in width, utilize more than one tape for sufficient coverage and identification of the duct bank as required.

When existing cables are to be placed in split duct, encased in concrete, the cable shall be carefully located and exposed by hand tools. Prior to being placed in duct, the RPR shall be notified so that he may inspect the cable and determine that it is in good condition. Where required, split duct shall be installed as shown on the drawings or as required by the RPR.

110-3.3 Conduits without concrete encasement. Trenches for single-conduit lines shall be not less than 6 inches nor more than 12 inches 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 the plans, a layer of fine earth material, at least 4 inches thick (loose measurement) shall be placed in the bottom of the trench as bedding for the conduit. The bedding material shall consist of soft dirt, sand or other fine fill, and it shall contain no particles that would be retained on a 1/4-inch sieve. The bedding material shall be tamped until firm. Flowable backfill may alternatively be used.

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 18 inches 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 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 apart (measured from outside wall to outside wall) in a horizontal direction and not less than 6 inches 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 apart (measured from outside wall to outside wall) in a horizontal direction and lot less than 6 inches 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 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 intervals. Spacers shall be in the proper sizes and configurations to fit the conduits. Locking collars and spacers shall be submitted to the RPR for review prior to use.

110-3.4 Markers. The location of each end and of each change of direction of conduits and duct banks shall be marked by a concrete slab marker 2 feet square and 4 - 6 inches thick extending approximately one inch above the surface. The markers shall also be located directly above the ends of all conduits or duct banks, except where they terminate in a junction/access structure or building. Each cable or duct run from a line of lights and signs to the equipment vault must be marked at approximately every 200 feet along the cable or duct run, with an additional marker at each change of direction of cable or duct run.

The Contractor shall impress words as indicated on the plans. Impression of letters shall be done in a manner, approved by the RPR, for a neat, professional appearance. All letters and words must be neatly stenciled. After placement, all markers shall be given one coat of high-visibility orange paint, as approved by the RPR. The Contractor shall also impress on the slab the number and size of conduits beneath the marker along with all other necessary information as determined by the RPR. The letters shall be 4 inches high and 3 inches wide with width of stroke 1/2 inch 1/4 inch 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. For conduits, 8 inches of sand, soft earth, or other fine fill (loose measurement) shall be placed around the conduits ducts and carefully tamped around and over them with hand tampers. The remaining trench shall then be backfilled and compacted per Item P-152 except that material used for back fill shall be select material not larger than 4 inches in diameter.

Flowable backfill may alternatively be used.

Trenches shall not contain pools of water during back filling operations.

The trench shall be completely backfilled and tamped level with the adjacent surface; except that, where sod is to be placed over the trench, the backfilling shall be stopped at a depth equal to the thickness of the sod to be used, with proper allowance for settlement.

Any excess excavated material shall be removed and disposed of per instructions issued by the RPR.

110-3.6 Backfilling for duct banks. After the concrete has cured, the remaining trench shall be backfilled and compacted per Item P-152 “Excavation and Embankment” except that the material used for backfill shall be select material not larger than 4 inches in diameter. In addition to the requirements of Item P-152, where duct banks are installed under pavement, one moisture/density test per lift shall be made for each 250 linear feet of duct bank or one work period’s construction, whichever is less.

Flowable backfill may alternatively be used.

Trenches shall not contain pools of water during backfilling operations.

The trench shall be completely backfilled and tamped level with the adjacent surface; except that, where sod is to be placed over the trench, the backfilling shall be stopped at a depth equal to the thickness of the sod to be used, with proper allowance for settlement.

Any excess excavated material shall be removed and disposed of per instructions issued by the RPR.

110-3.7 Ducts installed in pavement. Ducts installed in the pavement shall be constructed as detailed in the plans (see in-pavement trench details). Conduit trenches shall be backfilled with Item P-611 Quick Setting, High Early Strength Concrete. See Section L-125 for additional information and coordination with the base can installation.

110-3.8 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. Restoration with Item T-905 Topsoil and Item T-904 Sod will be as directed by the RPR.. The Contractor shall be held responsible for maintaining all disturbed surfaces and replacements until final acceptance. All restoration shall be considered incidental to the respective L-110 pay item. Following restoration of all trenching near airport movement surfaces, the Contractor shall thoroughly visually inspect the area for foreign object debris (FOD), and remove any such FOD that is found. This FOD inspection and removal shall be considered incidental to the pay item of which it is a component part.

110-3.9 Conduit pulling lubricant. The Contractor shall utilize an approved pulling lubricant to minimize frictional stresses developed during the cable pulling operation.

METHOD OF MEASUREMENT

110-4.1 Underground conduits and duct banks shall be measured by the linear feet of conduits and duct banks installed, including encasement, locator tape, trenching and backfill with designated material, and restoration, and for drain lines, the termination at the drainage structure, all measured in place, completed, and accepted as shown on the plans. Separate measurement shall be made for the various types and sizes, except for liquid-tight flexible steel conduit which will be considered a conduit connector. No separate measurement for conduit connectors shall be made, as it will be considered incidental.

Handholes and electrical vaults shall be measured per each, installed in place and accepted by the RPR as shown on the plans. All conduit connections to the handholes or light base cans shall be made per the plans and shall be considered incidental to the associated work.

BASIS OF PAYMENT

110-5.1 Payment will be made at the contract unit price per linear foot for each type and size of conduit and duct bank completed and accepted, including trench and backfill with the designated material, and, for drain lines, the termination at the drainage structure. This price shall be full compensation for removal and disposal of existing duct banks and conduits as shown on the plans, furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete this item per the provisions and intent of the plans and specifications.

Payment for handholes will be made at the contract unit price for each handhole accepted by the RPR. Said payment shall be full compensation for all of the items necessary to complete an acceptable unit of work, including the crushed aggregate bedding material.

Payment will be made under:

Item L-110-5.1 2" Schedule 40 PVC Conduit, Concrete Encased – per linear foot.

Item L-110-5.2 2” Rigid Galvanized Steel Conduit, Concrete Encased, In Pavement – per linear foot.

Item L-110-5.3 4” Schedule 40 PVC Conduit, Concrete Encased – per linear foot.

Item L-110-5.4 4” Rigid Galvanized Steel Conduit, Concrete Encased – per linear foot.

Item L-110-5.5 Two Way – 4" Schedule 40 PVC Conduit, Concrete Encased – per linear foot.

Item L-110-5.6 Two Way – 4” Rigid Galvanized Steel Conduit, Concrete Encased – per linear foot.

Item L-110-5.7 Handhole, Aircraft Rated – per each.

REFERENCES

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

Advisory Circular (AC)

AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-53	Airport Lighting Equipment Certification Program

ASTM International (ASTM)

ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

National Fire Protection Association (NFPA)

NFPA-70	National Electrical Code (NEC)

Underwriters Laboratories (UL)

UL Standard 6	Electrical Rigid Metal Conduit - Steel
UL Standard 514B	Conduit, Tubing, and Cable Fittings
UL Standard 514C	Nonmetallic Outlet Boxes, Flush-Device Boxes, and Covers
UL Standard 1242	Electrical Intermediate Metal Conduit Steel
UL Standard 651	Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings
UL Standard 651A	Type EB and A Rigid PVC Conduit and HDPE Conduit

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Item L-112 Horizontal Directional Drilling

DESCRIPTION

112-1.1 This section describes basic requirements for the installation of underground conduit using the horizontal directional drilling (HDD) method of installation. This method of construction is also commonly referred to as directional boring or guided horizontal boring.

112-1.2 Quality assurance. The requirements set forth in this section specify a wide range of procedural precautions necessary to insure that the very basic, essential aspects of a proper directional bore installation are adequately controlled. Strict adherence shall be required under specifically covered conditions outlined in this specification. Adherence to the specifications contained herein, or the Resident Project Representative (RPR) approval of any aspect of any directional bore operation covered by this specification, shall in no way relieve the Contractor of their ultimate responsibility for the satisfactory completion of the work authorized under the Contract.

112-1.3 Submittals. Prior to beginning work, the Contractor shall submit to the RPR a comprehensive work plan outlining the equipment, manpower, procedures and schedule to be used for HDD operations. The plan will also specifically deal with the method of access through the pavement and restoration of the launching and receiving pits. The contract documents reflect one acceptable method of completing the restoration but the RPR is willing to evaluate alternate proposals. This plan must be approved in whole prior to beginning operations in the field relative to horizontal directional drilling.

The Contractor shall submit specifications on HDD equipment and resumes of the superintendent and operators to be used to ensure that the equipment and manpower will be adequate to complete the project.

The Contractor shall submit specifications on all materials (conduit, fluid, etc.) to be used in HDD operations.

MATERIALS

112-2.1 General. The directional drilling equipment shall consist of a directional drilling rig of sufficient capacity to perform the bore and pull back the pipe, a drilling fluid mixing & delivery system of sufficient capacity to successfully complete the crossing, a guidance system to accurately guide boring operations and trained and competent personnel to operate the system. All equipment shall be in good, safe operating condition with sufficient supplies, materials and spare parts on hand to maintain the system in good working order for the duration of this project.

112-2.2 Drilling system. The drilling system is further described below as:

A. The directional drilling machine shall consist of a hydraulically powered system that develops 24,000 pounds of pullback capability and 4,000-foot pounds spindle torque. The hydraulically powered system shall rotate, push and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill (bore) head. The machine shall be anchored to the ground to withstand the pulling, pushing and rotating pressure required to complete the crossing. The hydraulic power system shall be self-contained with sufficient pressure and volume to power drilling operations. The hydraulic system shall be free of leaks. The rig shall have a system to monitor and record maximum pull-back pressure during pull-back operations. The rig shall be grounded during drilling and pull-back operations.

B. The drill head shall be steerable by changing its rotation and shall provide the necessary cutting surfaces and drilling fluid jets.

C. Mud motors shall be of adequate power to turn the required drilling tools.

D. Drill pipe shall be constructed of high quality 4130 seamless tubing, grade D or better, with

threaded box and pins. Tool joints should be hardened to 32-36 RC.

E. The use of high-pressure liquids or large liquid volume boring or drilling is not permitted.

112-2.3 Guidance system. The guidance system shall be of a proven type and shall be set up and operated by personnel trained and experienced with this system. The operator shall be aware of any magnetic anomalies and shall consider such influences in the operation of the guidance system if using a magnetic system.

112-2.4 Drilling fluid (MUD) system. A self-contained, closed, drilling fluid mixing system shall be of sufficient size to mix and deliver drilling fluid composed of bentonite clay, potable water and appropriate additives. Mixing system shall be able to molecularly shear individual bentonite particles from the dry powder to avoid clumping and ensure thorough mixing. Mixing system shall continually agitate the drilling fluid during drilling operations.

Drilling fluid shall be composed of clean water and an appropriate additive. Water shall be from a clean source with a pH of 8.5 to 10. Water of a lower pH or with excessive calcium shall be treated with the appropriate amount of sodium carbonate or equal. The water and additives shall be mixed thoroughly and be absent of any clumps or clods. No hazardous additives may be used. Drilling fluid shall be maintained at a viscosity sufficient to suspend cuttings and maintain the integrity of bore wall.

The mud pumping system shall have sufficient capacity and be capable of delivering the drilling fluid at a constant minimum pressure needed to accomplish the work. The delivery system shall have filters in-line to prevent solids from being pumped into the drill pipe. Connections between the pump and drill pipe shall be relatively leak-free. Used drilling fluid and drilling fluid spilled during drilling operations shall be contained and properly disposed of. A berm, minimum of 12" high, shall be maintained around drill rigs, drilling fluid mixing system, entry and exit pits and drilling fluid recycling system (if used) to prevent spills into the surrounding environment. Pumps and or vacuum truck(s) of sufficient size shall be in place to convey excess drilling fluid from containment areas to storage facilities.

112-2.5 Pipe rollers. Pipe rollers, if required, shall be of sufficient size to fully support the weight of the pipe while being hydro-tested and during pull-back operations. Sufficient number of rollers shall be used to prevent excess sagging of pipe.

112-2.6 Alternative drilling systems. Other devices or utility placement systems for providing horizontal thrust other than those defined in the preceding sections shall not be used unless approved by the RPR prior to commencement of the work. Consideration for approval will be made on an individual basis for each specified location. The proposed device or system will be evaluated prior to approval or rejection on its potential ability to complete the utility placement satisfactorily without undue stoppage and to maintain line and grade within the tolerances prescribed by the particular conditions of the project.

112-2.7 Conduit. Conduit installed through the HDD method described herein for airfield lighting cable and utility services owned by the FAA shall be High Density Polyethylene (HDPE) SDR 11 pipe. All connections shall conform with manufacturer’s recommendations and as detailed in the contract documents.

Conduit installed through the HDD method described herein for utility power services and communications not owned by the FAA may be HDPE SDR11 conduit of the specified size with a paralleling guard wire. Payment for utility services will be made per pay items included in Division 16 of these specifications.

Contractor shall endeavor to complete ductwork as shown on the plans or between junction structures without splicing. Where splices are required, the Contractor shall utilize the provided details or conform to industry standards. Continuity of the guard wire system (conduit or conductor) shall be maintained.

112-2.8 Liquidtight flexible steel conduit. Liquid-tight flexible steel conduit shall conform to Federal Spec. WW-C-566. Liquid-tight flexible steel conduit shall be limited to a maximum length of 6 ft., as

permitted by the NEC.

CONSTRUCTION METHODS

112-3.1 General. Prior to any excavation occurring, the Contractor shall insure that the dig permit process has occurred and the operator of the equipment has the dig permit available for inspection by authorized personnel.

Dig Permit: The subcontractor shall implement a dig permit system which records and lets each operator of an underground disturbing piece of equipment know that the utilities in his work area have been located and that he is clear to begin work. This process shall involve recording the date that each locating agency completed their utility locates, acknowledgement by the RPR and shall remain in/on the piece of equipment at all times. Failure to comply with the policy would result in immediate dismissal from the project. This procedure shall be developed and submitted to the RPR for approval as part of the subcontractor's site specific safety plan. The plan shall also include the notifications required in the event of an inadvertent cable cut for both those services that were and were not located by the appropriate owner.

The RPR must be notified 48 hours in advance of starting HDD work. The directional bore shall not begin until the RPR is present at the job site and agrees that proper preparations for the operation have been made. The RPR's approval for beginning the installation shall in no way relieve the Contractor of the ultimate responsibility for the satisfactory completion of the work as authorized under the Contract.

All HDD work performed shall be in accordance with laws, permits, requirements and regulations of the authority having jurisdiction of the Rights-of-Way.

Adequate barricades shall be erected to limit access to the HDD machine to operating personnel only.

Under no circumstances will the Contractor be allowed to cut or disturb pavement or excavate within the relative limits of the runway or taxiway surfaces to retrieve any lost boring apparatuses.

Drilling operations on the surface shall be no less than ten feet (10') from the edge of a runway or taxiway, or as required by the drawings and permits, unless approved by the RPR.

112-3.2 Personnel requirements. All personnel shall be fully trained in their respective duties as part of the directional drilling crew and in safety.

112-3.3 Drilling procedure. Prior to any alterations to the work site, the Contractor shall photograph or video tape the entire work area, including entry and exit points. One copy of which shall be given to the RPR and one copy to remain with the Contractor for a period of one year following the completion of the project.

The entire drill path shall be accurately surveyed with entry and exit stakes placed in the appropriate locations within the areas indicated on drawings. If the Contractor is using a magnetic guidance system, the drill path will be surveyed for any surface geo-magnetic variations or anomalies.

Environmental protection (in accordance with local ordinances) necessary to contain any hydraulic or drilling fluid spills shall be put in place, including berm, liners, turbidity curtains and other measures. The Contractor shall adhere to all applicable environmental regulations. Fuel or oil may not be stored in bulk containers within 200' of any water-body, wetlands or storm drainage inlet.

The Contractor shall calibrate the HDD head locator at the start of the day and at each new HDD operation. A daily calibration log shall be kept for the RPR's review.

The HDD operator shall have full control of the direction of the drilling tool at all times. Shallow, misdirected or other unsuccessful bores shall be abandoned and filled at the direction of the RPR at the expense of the Contractor,

In the event that a drilling fluid fracture, inadvertent returns or returns loss occurs during pilot hole drilling operations, the Contractor shall cease drilling, wait at least 30 minutes, inject a quantity of drilling fluid with a viscosity exceeding 120 seconds as measured by a March funnel and then wait another 30 minutes. If mud fracture or returns loss continues, the Contractor will cease operations and notify the RPR. The RPR and Contractor will discuss additional options and work will then proceed accordingly.

Upon successful completion of the pilot hole, the Contractor will ream the bore hole to a minimum of the outside diameter of the conduit but shall not exceed a maximum of 25% greater than the outside diameter of conduit using the appropriate tools. The Contractor will not attempt to ream at one time more than the drilling equipment and mud system are designed to safely handle.

Following the reaming head, the Contractor will pull the conduit through the bore hole. In front of the conduit will be a swiveling mandrel. Once pull-back operations have commenced, operations must continue without interruption until the conduit is completely pulled into the bore hole. During pull-back operations the Contractor will not apply more than the maximum safe pipe pull pressure at any time.

Standard power cable warning tape shall be pulled back on top of the casing pipe.

In the event that the conduit pipe becomes stuck during pull-back, the Contractor will cease pulling operations to allow any potential hydro-lock to subside and will commence pulling operations. If the pipe remains stuck, the Contractor will notify the RPR. The RPR and the Contractor will discuss options and then work will proceed accordingly.

When two new parallel ducts are called for, two independent bores shall be made and each shall be measured for payment.

At all launch and receiving pits, a backhoe or equivalent shall be used to gradually return the bore depth to the ditch prescribed depth.

All bore pits shall be back filled and compacted in accordance with the provisions of Item P-152. Backfill shall be consistent with backfill used for trench backfill. Surfaces shall be restored to original or better condition, utilizing 4-inch top soil per Section T-904 over sod per Section T-905, and to the satisfaction of the RPR and the governing authority.

112-3.4 Hydraulic or pneumatic conduit installation. Hydraulic or pneumatic conduit installation, such as “mole-shot”, may be utilized with the approval of the RPR to connect light base can locations which are sufficiently close to justify use of this installation method. The primary use of this installation method is anticipated to be the connection of the adjacent light base cans in the light pairs of a THL array.

112-3.5 Site restoration. Following drilling operations, the Contractor will de-mobilize equipment and restore the work-site to its original condition. All excavations will be backfilled and compacted to 95% of original density. Pavement surface finish shall be reinstalled consistent with the surrounding existing conditions as part of any pavement repairs or replacement. Landscaping will be restored to original condition.

112-3.6 Record keeping. The Contractor shall maintain a daily project log of drilling operations and a guidance system log with a copy given to the RPR at the completion of the project. As-built drawings shall be certified as to accuracy by the Contractor.

METHOD OF MEASUREMENT

112-4.1 Measurement. Measurement for horizontal directional drilling shall be per linear feet drilled, conduit installed, completed and accepted by the RPR. Separate measurement shall be made for different drilling sizes, except for liquid-tight flexible steel conduit which will be considered a conduit connector. Two parallel ducts shall be measured as two independent lengths of drilling, per linear foot.

All conduit connections to the handholes or light base cans shall be made per the contract documents and

shall be considered incidental to the associated work.

METHOD OF PAYMENT

112-5.1 Payment. Payment for horizontal directional drilling shall be made at the unit cost bid per linear feet drilled, conduit installed, completed and accepted by the RPR. Payment shall cover all materials, labor and equipment necessary to complete the specific item of work including, but not limited to, the creation of the launch pits, conduit splices including grounding as detailed in the contract documents and connections to light base cans. Final repairs to pavement surfaces disturbed for launch pits shall be measured and paid for separately.

Payment shall be made under:

L-112-5.1 Horizontal Directional Drilling, 4” HDPE Conduit – per linear foot

END OF ITEM L-112

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Item L-120 RWSL Shelter

DESCRIPTION

120-1.1 This item shall consist of erecting a Government Furnished Material (GFM) shelter on a Contractor constructed foundation in accordance with the design and dimensions shown in the plans. This work shall the furnishing of all incidentals necessary to place it in operating condition as a completed unit to the satisfaction of the Resident Project Representative (RPR). Included as a separate item of work shall be the installation of various pieces of electrical equipment including the wiring and terminations and the grounding systems installation (see Division 16, Electrical Work – RWSL Shelter and FAA Facilities).

MATERIALS

120-2.1 General. All materials and equipment used to construct this item shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Submittal data shall be presented in a clear, precise and thorough manner. Original catalog sheets are preferred. Photocopies are acceptable provided they are as good a quality as the original. Clearly and boldly mark each copy to identify pertinent products or models applicable to this project. Indicate all optional equipment and delete non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment for which they apply on each submittal sheet. Markings shall be boldly and clearly made with arrows or circles (highlighting is not acceptable). Contractor is solely responsible for delays in project accruing directly or indirectly from late submissions or resubmissions of submittals.

120-2.2 Concrete. The concrete for the vault shall be proportioned, placed, and cured in accordance with Item P-610, Structural Portland Cement Concrete.

120-2.3 Reinforcing steel. Reinforcing shall meet the requirements of Item P-610-2.10-Steel Reinforcement.

120-2.4 Electrical materials. Electrical materials shall conform to the requirements specified in Division 16.

120-2.5 Crushed aggregate base course. Bedding materials shall conform to the requirements specified in P-209.

120-2.6 Granular fill. Granular fill shall consist of pit-run gravel, sand or crushed gravel placed in compliance with P-152.

CONSTRUCTION METHODS

120-3.1 General. The Contractor shall construct the shelter foundation at the location indicated in the plans. The foundation shall be reinforced concrete of the type specified and detailed in the Contract Documents. The Contractor shall provide all labor and equipment necessary to place the government provided shelter on the Contractor constructed foundation. All excavation, embankment and bedding stone shall comply with Items P-152 and P-209.

The Contractor shall clear, grade, seed and generally make site improvements as detailed in the plans. The slope shall be not less than ½-inch per foot away from the shelter in all directions.

120-3.2 Foundation. The Contractor shall construct the foundation in accordance with the details shown in the plans. Unless otherwise specified, internal ties shall be of the mechanical type so that when the forms are removed the ends of the ties shall be at least 1-inch beneath the concrete surface; the holes shall be plugged and finished to prevent discoloration. Reinforcing steel shall be placed, as shown in the drawings, and secured in position to prevent displacement during the concrete placement.

The external surfaces of the concrete shall be thoroughly worked during the placing operation to force all coarse aggregate from the surface. Thoroughly work the mortar against the forms to produce a smooth finish free from air pockets and honeycomb.

Broom finish shall be applied to the top surface of the concrete.

120-3.3 Conduits through foundation. Conduits shall be installed through the foundation in accordance with the details shown in the plans. All incoming conduits shall be closed with a pipe plug to prevent the entrance of foreign material during construction.

120-3.4 Erection plan. The Contractor shall develop and submit for approval, a "picking" plan, detailing the equipment to be used in setting the prefabricated structure on the constructed foundation. Said plan shall work within the parameters used to develop the FAA 7460 Airspace Study and a shelter weight of approximately 20,000 pounds.

METHOD OF MEASUREMENT

120-4.1 The quantity of shelters to be paid for under this item shall consist of the number of government furnished shelters erected on Contractor constructed foundations in place and accepted as a complete unit.

120-4.2 No separate measurement will be made for any of the various items required for site improvements within this specification but will be made as specified in the particular item of work (see the appropriate specification item).

BASIS OF PAYMENT

120-5.1 The lump sum bid for these items shall be considered full payment 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 each shelter installation to the satisfaction of the RPR. No separate payment shall be made to restore existing conditions, as this work is considered incidental. Payment for various items required for site improvements requiring P-152 or P-209 will be made under that particular item of work.

120-5.2 Partial payments shall be made as follows:

A. Fifty percent (50%) of each Lump Sum item will be paid when the foundation and stoop is complete.

B. Twenty-five percent (25%) of each Lump Sum item will be paid when the shelters are received, set and anchored to the foundation.

C. The final twenty-five percent (25%) of each Lump Sum item will be paid when all work is complete.

120-5.3 Payment will be made under:

Item L-120-5.1 RWSL Shelter No. 1 - per lump sum

END OF ITEM L-120

Item L-125 Installation of Airport Lighting Systems

DESCRIPTION

125-1.1 This item shall consist of airport lighting systems furnished and installed in accordance with this specification, the referenced specifications, and the applicable advisory circulars (ACs). The systems shall be installed at the locations and in accordance with the dimensions, design, and details shown in the plans. This item shall include the furnishing of all equipment, materials, services, and incidentals necessary to place the systems in operation as completed units to the satisfaction of the RPR.

125-1.2 References. Requirements of Item L-100 apply to this specification.

EQUIPMENT AND MATERIALS

125-2.1 General.

a. Airport lighting equipment and materials covered by Federal Aviation Administration (FAA) specifications shall be certified under the Airport Lighting Equipment Certification Program in accordance with AC 150/5345-53, current version. FAA certified airfield lighting shall be compatible with each other to perform in compliance with FAA criteria and the intended operation. If the Contractor provides equipment that does not performs as intended because of incompatibility with the system, the Contractor assumes all costs to correct the system for to operate properly.

b. Manufacturer's certifications shall not relieve the Contractor of their responsibility to provide materials in accordance with these specifications and acceptable to the RPR. Materials supplied and/or installed that do not comply with these specifications shall be removed, when directed by the RPR and replaced with materials, which do comply with these specifications, at the sole cost of the Contractor.

c. All materials and equipment used shall be submitted to the RPR for approval prior to ordering the equipment. Submittals consisting of marked catalog sheets or shop drawings shall be provided. Clearly mark each copy to identify pertinent products or models applicable to this project. Indicate all optional equipment and delete non-pertinent data. Submittals for components of electrical equipment and systems shall identify the equipment for which they apply on each submittal sheet. Markings shall be clearly made with arrows or circles (highlighting is not acceptable). The Contractor shall be responsible for delays in the project accruing directly or indirectly from late submissions or resubmissions of submittals.

d. The data submitted shall be sufficient, in the opinion of the RPR, to determine compliance with the plans and specifications. The Contractor's submittals shall be submitted in electronic PDF format, tabbed by specification section. The RPR reserves the right to reject any or all equipment, materials or procedures, which, in the RPR’s opinion, does not meet the system design and the standards and codes, specified herein.

e. All equipment and materials furnished and installed under this section shall be guaranteed against defects in materials and workmanship for a period of at least 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.

All LED light fixtures must be warranted by the manufacturer for a minimum of 4 years after date of installation, inclusive of all electronics.

EQUIPMENT AND MATERIALS

125-2.2 Conduit/Duct. Conduit shall conform to Specification Item L-110 Airport Underground Electrical Duct Banks and Conduits.

125-2.3 Cable and Counterpoise. Cable and Counterpoise shall conform to Item L-108 Underground Power Cable for Airports.

125-2.4 Tape. Rubber and plastic electrical tapes shall be Scotch Electrical Tape Numbers 23 and 88 respectively, as manufactured by 3M Company or an approved equal.

125-2.5 Cable Connections. Cable Connections shall conform to Item L-108 Installation of Underground Cable for Airports.

125-2.6 Retroreflective Markers. Not required.

125-2.7 Runway and Taxiway Lights. Runway and taxiway lights shall conform to the requirements of AC 150/5345-46. Lamps shall be of size and type indicated, or as required by fixture manufacturer for each lighting fixture required under this contract. Filters shall be of colors conforming to the specification for the light concerned or to the standard referenced. L-852S (REL) and L-850T (THL) fixtures shall be approved by the FAA prior to ordering.

LIGHTS

Type	Class	Mode	Style	Option	Base	Filter	Transformer	Notes
L-852S	2	1	3	N/A	L-868B	R/O	L-830-3	-
L-850T	2	1	3	N/A	L-868B	R/O	L-830-3	-

125-2.8 Runway and Taxiway Signs. Not required.

125-2.9 Runway End Identifier Light (REIL). Not required.

125-2.10 Precision Approach Path Indicator (PAPI). Not required.

125-2.11 Cover Plates. All cover plates shall meet the requirements of AC 150/5345-42. Solid cover plates for existing L-868 bases shall be 3/4-inch thick minimum and provided by the Contractor. The top of bolts attaching cover plates to base cans shall be flush or 1/8-inch below the adjacent pavement. Contractor shall use spacer rings to adjust elevation of cover plates.

125-2.13 Circuit Selector Cabinet. Not required.

125-2.13 Light Base and Transformer Housings. Light Base and Transformer Housings should conform to the requirements of AC 150/5345-42. Light bases shall be Type L-868, Class 1B, Size B and shall be provided as indicated or as required to accommodate the fixture or device installed thereon. Base plates, cover plates, and adapter plates shall be provided to accommodate various sizes of fixtures.

125-2.14 Sealant. Sealant shall conform to the requirements of FAA specifications for sealant and the details herein. Sealant for around fixture top flange and spacer rings in concrete shall be P-605, P-606, or approved equal. Subcontractor shall not employ the use of Gardox sealant products.

125-2.15 Isolation Transformers. Isolation Transformers shall be Type L-830, size as required for each installation. Transformer shall conform to AC 150/5345-47.

125-2.16 RWSL Individual Light Controller (ILC). The RWSL ILC shall be the LINC 360 Remote, manufactured by ADB Safegate. One RWSL ILC shall be installed for each RWSL fixture installed. RWSL ILCs shall be placed in the base can and connected between the Isolation Transformer and the RWSL fixture, as shown in the plans.

125-2.17 Bolting Hardware. Fixture bolts attaching RWSL fixtures or cover plates shall be 18-8 stainless steel for galvanized steel base cans. All other hardware, such as cap screws, set screws, tap bolts, nuts, washers, hinges, etc., for the RWSL installation shall be stainless steel Type 316, SAE Grade 2.

INSTALLATION

125-3.1 Installation. The Contractor shall furnish, install, connect and test all equipment, accessories, conduit, cables, wires, buses, grounds and support items necessary to ensure a complete and operable airport lighting system as specified here and shown in the plans.

The equipment installation and mounting shall comply with the requirements of the National Electrical Code and state and local code agencies having jurisdiction.

The Contractor shall install the specified equipment in accordance with the applicable advisory circulars and the details shown on the plans.

125-3.2 Testing. All lights shall be fully tested by continuous operation for not less than 24 hours as a completed system prior to acceptance. The test shall include operating the constant current regulator in each step not less than 10 times at the beginning and end of the 24-hour test. The fixtures shall illuminate properly during each portion of the test.

125-3.3 Shipping and Storage. Equipment shall be shipped in suitable packing material to prevent damage during shipping. Store and maintain equipment and materials in areas protected from weather and physical damage. Any equipment and materials, in the opinion of the RPR, damaged during construction or storage shall be replaced by the Contractor at no additional cost to the owner. Painted or galvanized surfaces that are damaged shall be repaired in accordance with the manufacturer's recommendations.

125-3.4 Elevated and In-pavement Lights. Water, debris, and other foreign substances shall be removed prior to installing fixture base and light.

A jig or holding device shall be used when installing each light fixture to ensure positioning to the proper elevation, alignment, level control, and azimuth control. Light fixtures shall be oriented according to the Contract drawings. The outermost edge of fixture shall be level with the surrounding pavement. Surplus sealant or flexible embedding material shall be removed. The holding device shall remain in place until sealant has reached its initial set.

Each light fixture shall be grounded to the internal ground lug of the base can with a 36-inch braided ground strap equal to the #6 AWG wire as shown on the plans.

Bolts used to connect the fixture to the base can is required to be coated with an approved anti-seize coating and used with a 2-piece lock washer. The following procedures for bolt installation is recommended by the manufacturer:

For fixtures installed on standard galvanized steel base cans:

1. Use 18-8 stainless steel bolts with 2-piece locking washer sets.
2. Provide material submittal of anti-seize compound to Engineer for approval prior to use.
3. Torque bolts to 151 in-lbs.

Final fixture installation shall be checked at night and shall be to the satisfaction of the Engineer. All lines of light shall be continuous without breaks or blackout spots as viewed by the Engineer from a vehicle.

125-3.5 Isolating Transformers. The isolation transformers shall be placed in the base can as shown on the plans. The primary and secondary cable connections shall be made as shown on the plans.

Provide 3-foot slack cable inside the base can to permit connections of both primary leads to the transformer outside the base can.

125-3.6 Individual Light Controllers (ILC). The Individual Lighting Controllers primary and secondary cable connections shall be installed as shown on the plans. Each ILC shall be grounded to the internal ground lug of the base can with a 36-inch braided ground strap equal to #6 AWG wire as shown on the plans.

125-3.7 Corrective Action. The Subcontractor shall be responsible for correcting any deficient condition (installed under this contract) identified during the testing. If retesting of corrected conditions can be completed within the originally scheduled field test period, and then retesting shall be performed to verify that any deficient condition has been successfully corrected.

METHOD OF MEASUREMENT

125-4.1 Equipment to be paid for under this item shall be for each equipment unit installed, connected, sealed, aligned, and accepted as a complete unit ready for operation and accepted as satisfactory by the Engineer.

BASIS OF PAYMENT

125-5.1 Payment will be made at the Contract unit price for each fixture type installed in place by the Subcontractor and accepted by the Engineer.

Payment for installation of Runway Entrance Lights in new base cans shall be full compensation for furnishing all labor, equipment, tools, materials, and incidentals necessary to complete this item, including fixture, fixture bolts, lock washers, flange and spacer rings, base can, isolation transformer, Individual Light Controller, connectors, ground rods, ground straps, bare copper ground wire, core drilling, concrete backfill, dowels and rebar cages, disposal off-site of waste materials, pavement restoration, and testing.

Payment for installation of the steel cover plate shall be full compensation for the labor necessary to furnish and install new steel cover plates, including bolts and lock washers, on a base can, whether temporarily or permanently, and to deliver existing steel cover plates to the Airport.

Payment for installation of Runway Entrance Lights or Takeoff Hold Lights in existing base cans shall be full compensation for furnishing all labor, equipment, tools, materials, and incidentals necessary to complete this item, including fixtures, fixture bolts, lock washers, isolation transformer, Individual Light Controller, connectors, ground straps and testing.

Payment will be made under:

Item L-125-5.1	Runway Entrance Light - per each
Item L-125-5.2	Installation of 3/4” Cover Plate – per each
Item L-125-5.3	Runway Entrance Light in Existing Base Can - per each
Item L-125-5.4	Takeoff Hold Light in Existing Base Can - per each

REFERENCES

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

Advisory Circulars (AC)

AC 150/5340-18	Standards for Airport Sign Systems
AC 150/5340-26	Maintenance of Airport Visual Aid Facilities
AC 150/5340-30	Design and Installation Details for Airport Visual Aids
AC 150/5345-5	Circuit Selector Switch
AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuits
AC 150/5345-26	Specification for L-823 Plug and Receptacle, Cable Connectors
AC 150/5345-28	Precision Approach Path Indicator (PAPI) Systems
AC 150/5345-39	Specification for L-853, Runway and Taxiway Retroreflective Markers
AC 150/5345-42	Specification for Airport Light Bases, Transformer Housings, Junction Boxes, and Accessories
AC 150/5345-44	Specification for Runway and Taxiway Signs
AC 150/5345-46	Specification for Runway and Taxiway Light Fixtures
AC 150/5345-47	Specification for Series to Series Isolation Transformers for Airport Lighting Systems
AC 150/5345-51	Specification for Discharge-Type Flashing Light Equipment
AC 150/5345-53	Airport Lighting Equipment Certification Program

Engineering Brief (EB)

EB No. 67	Light Sources Other than Incandescent and Xenon for Airport and Obstruction Lighting Fixtures

END OF ITEM L-125

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Item L-130 Airfield Electrical Installation Testing

DESCRIPTION

130-1.1. This item shall consist of performing all tasks necessary to prove proper performance of electrical and airfield lighting systems. Airfield lighting systems include Runway Status Lights installation consisting of Takeoff Hold Light (THL) circuits and Runway Entrance Light (REL) circuits.

Drawings, general provisions and special provisions of the Contract Documents, including Contractual Conditions and Division 1 Specification sections apply to this Item.

This section describes the electrical quality control testing furnished by the Contractor. The

Contractor shall provide all testing as required by this item, including retesting of failed items. All items furnished and/or installed by the Contractor shall be tested in accordance with this item.

The Contractor shall provide for all electrical testing to confirm that the installations associated with this project comply with the Contract Documents. Contractor shall engage an independent organization to perform the Hi-Pot Testing with the Contractor providing all testing assistance.

The Contractor shall furnish all equipment, labor, supervision, transportation, materials and appliances necessary or required for testing the airport lighting systems before and after installation. The Contractor shall perform all tests in the presence of the Resident Project Representative (RPR). The Contractor shall demonstrate the electrical characteristics to the satisfaction of the RPR. All costs for testing are incidental to the pay item for the respective item being tested.

Any system installation errors or discrepancies of installation not in conformance with the Contract Documents shall be corrected at no additional cost. Equipment, cables and other components which do not satisfy the test requirements of this Item shall be removed and replaced with new equipment, cables and other components which do satisfy the requirements of this item including any necessary retesting required to confirm that the discrepancy has been corrected.

Weather information necessary to complete the testing forms may be obtained from the listed website http://www.faa.gov/air_traffic/weather/asos/ by selecting on the respective state and airport ID.

MATERIALS

130-2.1 Submittals. Materials and equipment covered by this item shall be subject to acceptance through manufacturer's certification of compliance with the applicable specification when requested by the RPR. All equipment, materials, methods and record keeping procedures shall be submitted to the RPR for review.

The submittal shall include a list of the proposed test and measurement equipment to be used, the test and measurement equipment serial number, the current calibration certificate for each piece of equipment and a written description of the proposed test. A copy of the test and measurement equipment manufacturer's recommended test procedure is acceptable as a written description of the proposed test.

The Contractor shall submit the qualifications of the organization performing the Hi-Pot testing. The submittal shall include:

A. The organizations name and address.

B. References for the organization from five previous air carrier airports with similar jobs to include names and phone numbers.

C. A complete list of all tests, measurement equipment and all accessories proposed for use including the serial numbers of the equipment and a copy of the respective calibration certificates.

D. Test procedures and safety precautions required during testing.

E. Qualifications and experience of persons performing the testing.

F. References for the person designated to perform the testing from five previous similar jobs to include names and phone numbers.

Submit a proposed field test plan, 30 days prior to testing the installed system. No field test shall be performed until the test plan is approved. The test plan shall consist of complete field test procedures including tests to be performed, test equipment required, and tolerance limits. The Contractor shall submit a complete list of required tests and a proposed schedule and duration of the tests. The schedule shall be integrated with the overall project schedule. The Contractor shall update the testing schedule on a monthly basis for the duration of the project.

All test results shall be submitted in a bound report no later than two weeks after the completion of all testing.

130-2.2 Safety. Dangerous voltages are present during the system testing. The Contractor is solely responsible for the safety of all personnel involved in the testing activities and shall ensure that all testing areas are secured to prevent the entry of unqualified personnel.

Observe all safety instructions or precautions recommended by testing equipment manufacturer.

The Contractor shall perform a "Hazard/Risk Evaluation" of each test site and procedure. The

Contractor shall provide a job briefing and install the necessary barriers and barricades at the respective approach boundaries prior to starting the testing.

The Contractor shall provide and use safety devices such as rubber gloves, protective barriers, and danger signs to protect and warn personnel in the test vicinity. The Contractor shall replace any devices or equipment which are damaged due to improper test procedures or handling.

In addition to compliance with the Contractors safety program, the Contractor shall comply with the following documents/programs:

OSHA, 29CFR1910 Occupational Safety and Health Standards

OSHA 29CFR1926 Safety and Health regulations for Construction

NFPA 70B Recommended Practice for Electrical Equipment Maintenance

NFPA 70E Standard for Electrical Safety in the Workplace

AC 150/5340-26 Maintenance of Airport Visual Aid Facilities

Airport's safety program.

130-2.3 Qualifications. Each person performing testing shall have a minimum of 5 years of successful experience on similar projects. At least 3 of these years of experience shall have occurred in the last 5 years on projects of comparable size and complexity. Persons performing the testing shall have passed a proctored Journeyman Electrician's exam with 75% grade or better and be a commercial licensed Journeyman Electrician. Equivalent training and experience may be considered by the RPR. Documentation demonstrating compliance with these requirements shall be submitted to the RPR for verification and review before starting the testing. Experience records shall include references (names and phone numbers) from airports where the test procedures have been performed in a satisfactory manner. Only persons whose experience records have been confirmed by the RPR shall perform testing.

The person performing the tests shall be a "qualified person" as defined in NFPA 70E.

The person performing the tests shall be thoroughly familiar with the test equipment used in the test performed and shall be sufficiently experienced to detect equipment abnormalities or questionable data obtained during the test procedure.

Each piece of test and measurement equipment utilized to demonstrate compliance with the Contract Documents shall be calibrated. The level of calibration shall be *"NIST traceable, Z540 Calibration with Data*". The test and measurement equipment calibration shall be valid for one year. At any time the RPR may require the Contractor to have a piece of test equipment recalibrated. Should the RPR have any reason to doubt the accuracy of a piece of test equipment, even within current calibration, the test and measurement equipment shall be removed from the project. The RPR shall determine which tests shall be redone due to the malfunctioning equipment.

The test and measurement equipment calibration lab as a minimum shall meet the requirements of ANSI/NCSL Z-540 and shall be A2LA accredited.

The High Potential (Hi-Pot) tests shall be performed by an independent agency certified by the

National Electrical Testing Association (NETA) with certified technicians using properly calibrated equipment and standard procedures.

130-2.4 Testing coordination. After installation of all required components and before final acceptance, in accordance with project phasing and schedule make required tests to determine proper function of all circuits.

Ten days prior to any testing the Contractor shall notify the RPR of the tentative start of testing. Together, a mutually agreed upon schedule of testing will be developed. All requirements under this item shall be coordinated with the RPR.

The Contractor shall perform the necessary inspection and tests for some items concurrently with the installation because of subsequent inaccessibility of some components.

The Contractor shall ensure that all test and measurement equipment, accessories and qualified personnel are available prior to scheduling tests.

All test results shall be recorded by the Contractor and witnessed by the RPR or designated representative, unless the RPR has provided written instruction to proceed in the RPR's absence. Test results shall be submitted in a bound report after the specified testing is completed.

The Contractor is reminded that due to phasing constraints, any outside testing agencies utilized may have multiple mobilizations required to test airfield lighting systems as each area is completed. For projects completed in phases, the respective required testing must be completed by phase.

130-2.5 Test and measurement equipment. Electrical test and measurement equipment shall be an off the shelf item, not a one of a kind prototype. The test and measurement equipment shall be manufactured by a firm regularly engaged in the manufacture of precision electrical test and measurement equipment for the industrial, commercial and utility marketplace. Typical accuracy for test equipment shall be + 2% of instrument reading and shall be TRUE RMS.

The RPR shall confirm that the test and measurement equipment proposed for use by the

Contractor is suitable for the intended use. The RPR shall have sole discretion to determine if the test and measurement equipment is suitable for the intended use.

The ground point for the cable test equipment shall be the shelter ground bus. The shelter ground bus, shelter ground system, and airfield guard wire system shall be complete prior to cable testing.

CONSTRUCTION METHODS

130-3.1 Guard wire and earth electrode system testing. Continuity of guard wire and Earth Electrode Systems (EES) shall be checked by visual inspection as construction progresses, prior to work being covered up. Verification of guard wire system continuity shall also be checked by visual inspection at accessible locations during normal inspections.

Should the guard wire or earth electrode system conductors be damaged or are suspected to be damaged by construction activities (in the opinion of the RPR) the Contractor shall test the conductors for continuity with a micro-ohmmeter. The conductors shall be isolated such that there is no parallel path. Alternatively, the Contractor may conduct tests and through mathematical computations prove the continuity of the conductors.

Investigate unsatisfactory results and make necessary corrections or replacements as required by the Contract Documents.

Verification of the adequacy of the guard wire and earth electrode systems shall be by taking earth resistance measurements as detailed below. Earth resistance measurements shall be made in normally dry conditions not less than 48 hours after the last rainfall.

Initially the Contractor shall test each ground rod in accordance with the following instructions. The horizontal distance between the Ground Electrode under Test (Electrode **X**) and the Auxiliary Current Electrode (Electrode **Z**) shall be 4 times the depth (length) of the ground electrode under test.

The three electrodes shall be installed in a straight line in a direction away from other underground metallic items. The test leads shall be separated.

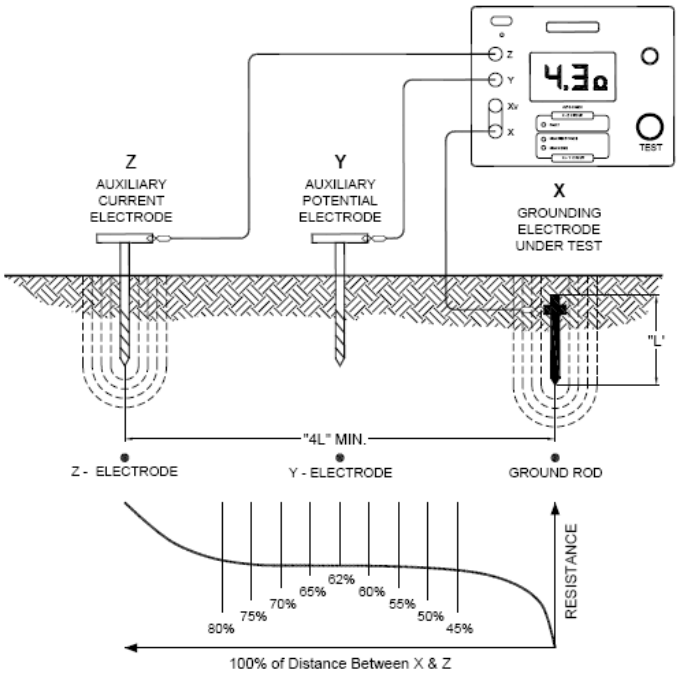
The first test shall be conducted with the Auxiliary Potential Electrode (Electrode **Y**) at 45% of the distance between the **X** and **Z** electrodes. The earth resistance shall be measured and recorded at the 45% position. The **Y** electrode will then be moved 5% closer to the **Z** electrode to the 50% position and the earth resistance shall be measured and recorded. The previous steps will be repeated at 5% distance intervals through the 80% position. Graph the resultant points on the form provided at the end of this item.

The above test method shall be utilized at each new ground rod installation until otherwise determined by the RPR. The RPR will use the acquired data to establish a revised distance ratio between the **X** and **Z** electrode.

Once the new electrode distance ratio is set by the RPR, the Contractor may perform the tests with a single test position for electrode **Y**.

Earth resistance tests shall be performed as each ground rod is installed. Earth resistance tests shall be conducted prior to the connection of any grounded, earth electrode system or guard wire conductors. Ground rods not in compliance with the not to exceed maximum earth resistance shall have an additional 10’ section(s) added until the required earth resistance is achieved.

The Earth Electrode System and Guard Wire Systems shall be tested individually. After satisfactory testing is completed on each system, the EES and Guard Wire System shall be terminated together.



130-3.2 New airfield lighting circuit continuity testing. After new cable installation and before the Hi-pot test or power applied, the airfield lighting series circuit cable system shall be given a circuit internal resistance (continuity) test.

This test shall be conducted at the high voltage output cabinet where the L-824C cables enter the facility used to house the Constant Current Regulator (CCR) and shall be used to prove continuity of the entire circuit. All L-824C cables are to be disconnected from the surge arrester assemblies inside the high voltage output box and all circuits not being tested shall be grounded to the EES. The Contract Documents shall be reviewed to confirm proper circuit routing, connection and installation of necessary components prior to testing.

The cable, connectors, isolation transformers, ILCs and fixtures shall be in their final configurations ready for connection to the constant current regulator (CCR).

The EES and Guard Wire System shall be terminated together.

Observe all OSHA required safety precautions.

The circuit's internal resistance (continuity) test shall be performed using an ohmmeter with sufficient output to measure the circuit's internal resistance. The expected internal circuit resistance should be within 20 percent of calculated value shown in calculations shown under "Calculations" Section of these Specifications.

Investigate unsatisfactory results and make necessary corrections or replacements as required by the Contract Documents.

Upon successful completion of circuit's internal resistance (continuity) test, record the measured circuits internal resistance on the cable test form included at the end of this item.

130-3.3 New airfield lighting circuit insulation resistance testing. The circuit insulation resistance test (megger test) may be used to verify the continuity of a L-824C cable or circuit during construction of each phase or lighting array.

The airfield lighting circuit insulation resistance test shall be performed with a megohmmeter providing a test voltage of 1,000 volts DC. The output of the megohmmeter shall be direct reading in megohms and shall have an upper range limit of at least 10 gigohms or greater.

Observe all OSHA required safety precautions such as safety glasses (or face shield), hot gloves, fireproof clothing, etc.

Ground all other conductors within the conduits or ducts containing the conductor under test.

Connect the test instrument in accordance with the manufacturer's recommendations. Record data at the required intervals on the form provided at the end of this Item. The insulation resistance measurement results shall be corrected to 20 degrees Centigrade (68 degrees Fahrenheit).

The expected insulation resistance for the completed circuit should be in excess of 50 megohms.

Investigate unsatisfactory results and make necessary corrections or replacements as required by the Contract Documents.

Upon successful completion of circuit's insulation resistance test, record the measured circuits internal resistance on the cable test form included at the end of this item.

130-3.4 New airfield lighting circuit high potential testing. Prior to performing the Hi-pot test, the circuit continuity test must be completed and any discrepancies in the circuit corrected.

This test shall be conducted at the high voltage output cabinet where the L-824C cables enter the facility used to house the Constant Current Regulator (CCR). All L-824C cables are to be disconnected from the surge arrester assemblies inside the high voltage output box and any cables not being tested must be grounded to the EES.

The cable, connectors, isolation transformers, ILCs and fixtures shall be in their final configuration, ready for connection to the constant current regulator (CCR).

Warning, this test is being conducted with 10kV; observe all OSHA required safety precautions.

In damp conditions, humidity, condensation and actual precipitation on the surface of a cable termination can increase the leakage current by several orders of magnitude. Humidity also increases the corona current, which indication is included in the total leakage current. The Contractor shall evaluate the conditions and determine if the safety requirements are being met.

The airfield lighting circuit Hi-Pot test shall be performed with a calibrated high voltage test set which has steady, filtered direct current output voltage. The high voltage test set shall include an accurate voltmeter and microammeter for reading the voltage applied to the circuit and resultant insulation leakage current.

Ground all other conductors within the high voltage output cabinet containing the conductor under test.

Clean and dry the cable under test for a distance of 1 foot from the ends.

Connect one lead of the Hi-Pot test instrument to the cable and the other lead to the EES.

At the end of each test, discharge the cable with a hot stick to the EES.

The Hi-Pot test shall be conducted for ten (10) minutes). Step the voltage up, hold and down in accordance with the test form included at the end of this item. Record data at the required intervals on the form provided at the end of this Item. The insulation resistance measurement results shall be corrected to 20 degrees Centigrade (68 degrees Fahrenheit).

Insulation leakage current shall be measured and recorded for each circuit after a 1 minute application of the test voltage. If leakage current exceeds values specified below, the circuit shall be sectionalized and retested and the defective parts shall be repaired or replaced. Leakage current limits include allowances for the normal number of connectors and splices for each circuit as follows:

A. Three microamperes for each 1000 feet of cable.

B. Two microamperes for each 5,000-volt series transformer.

If the measured value of insulation leakage current exceeds calculated value, the circuit shall be sectionalized and tested as specified for each section. Defective components shall be corrected or replaced until repeated tests indicate an acceptable value of leakage current for the entire circuit.

Investigate unsatisfactory results and make necessary corrections or replacements as required by the Contract Documents.

Upon successful completion of the high potential test on all L-824C circuits within the facility terminate L-824C cables to the surge assemblies.

130-3.5 Constant current regulator (CCR) tests. Each constant current regulator shall be examined to ensure that porcelain bushings are not cracked, no shipping damage has occurred, internal and external connections are correct, switches and relays operate freely and are not tied or blocked, fuses, if required, are correct, and liquid level of liquid-filled regulators is correct. Relay panel covers shall be removed only for this examination; it is not necessary to open the main tank of liquid-filled regulators. The Contractor shall comply with the manufacturer's startup and operational instructions. Covers shall be replaced tightly after completing examinations and tests.

Verify the supply voltage and nameplate input voltage are the same. Verify CCR is properly grounded. With the loads disconnected, regulator shall be energized and the open circuit protector observed to ensure that it de-energizes the regulator within 2 seconds.

Comply with the manufacturer's recommendation for calibration and set up of each new CCR and each existing CCR connected to a new or modified airfield lighting circuit. The regulator output current and voltage shall be calibrated using a true RMS meter. The CCR calibration shall be complete prior to making any other CCR measurements.

Verify all airfield lighting fixtures and loads are operational. Each circuit shall then be operated manually through each brightness step a minimum of ten times with the circuit in operation a minimum of five minutes on each operation. In addition, each circuit shall operate a minimum of four hours on high step with no noticeable intensity difference in the lighting or operational problems.

Complete an Airfield Lighting Circuit Data Sheet for each new CCR. A sample Airfield Lighting Circuit Data Sheet is included at the end of this Item.

Record notable current, voltage or power wave forms of the circuits tested to demonstrate and identify normal operation and any unusual circuit characteristics.

Comply with the manufacturer's recommendation for calibration and set up of each new CCR and each existing CCR connected to a new or modified airfield lighting circuit. The regulator output current and voltage shall be calibrated using a true RMS meter. The CCR calibration shall be completed prior to turning the circuit over to Saab Sensis for system integration testing.

Investigate unsatisfactory results and make necessary corrections or replacements as required by the Contract Documents.

Perform required testing to complete information requested on the Airfield Lighting Circuit Data Sheet.

METHOD OF MEASUREMENT

130-4.1. The items described in this section shall be measured as a lump sum; no direct measurement shall be made.

BASIS OF PAYMENT

130-5.1 Basis of payment. The lump sum bid for this item shall be considered full payment for providing all labor, equipment and manpower necessary to complete the stipulated testing and submit the report in a timely manner.

Payment will be made under:

L-130-5.1 Airfield Electrical Testing – per Lump Sum

AIRFIELD LIGHTING CIRCUIT DATA SHEET

Circuit Designation:		Date:	
Circuit Description:		Ph. Wire Size/Type:	
Source Panel/Ckt		GND. Wire Size/Type:	
Panel ∅; CB Size:		Conduit Size/Type:	
CCR Size:		CCR Output Amps:	
CCR Manufacturer:		Yr. Manufactured:	
CCR Type No.:		Part No.:	
Output Amp Steps:	/ / / /		
Input Volts:	Ph.: Hz.:	Input Amps:	
Control Voltage:		Serial Number:	
Oil Capacity:	**Gal.** Oil Test Date:	Weight:	**lbs.**
CCR Insp./Calib.:	Date:	Circuit Age:	**Years**
Insul. Resist. at 1 min.:	**Ω @ 1000 V**	Weather:	
Lamps in Ckt.:	Lamp Watts:	Lamps Out:	

Manufacturer's Set up and Calibration Completed by: _____

	Calibration	LOAD TEST							
Step	Output Amps	Output Amps	Output Voltage	Output KVA	Output PF	Input Amps	Input Volts	Input KVA	Input PF
B1/B10									
B2/B30									
B3/B100									
B4									
B5									

Comments:

Earth Resistance Test

Instrument Mfg. _____ Test Date _____

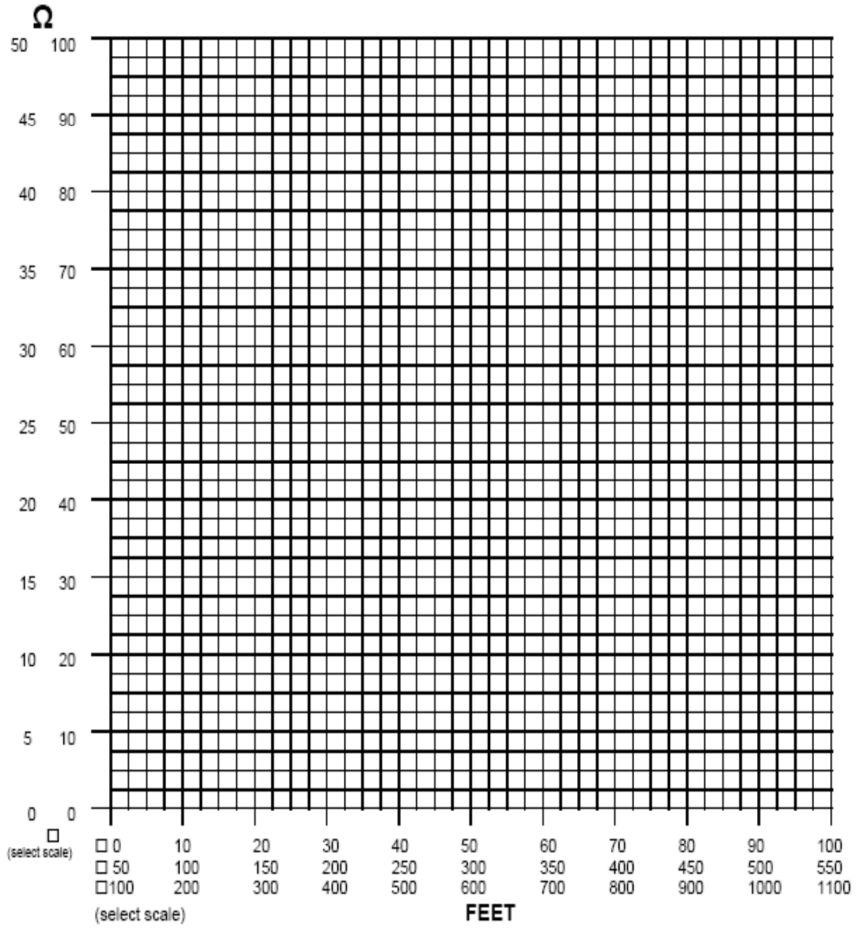
Model _____ Operator Name _____

Serial Number _____ Test Location _____

Test Conditions	
Soil Condition: ☐ Moist ☐ Dry	Temperature _____ °F °C
Soil Type: (choose one)	☐ Clay ☐ Limestone ☐ Sand & Gravel ☐ Granite ☐ Shale ☐ Sandstone ☐ Loam ☐ Slate ☐ Other _____

Weather Conditions
Relative Humidity: _____
Precipitation Accumulation: _____
Sky Conditions: _____
Grounding System
☐ Single Rod
Rod Depth _____ft

%	Voltage Electrode (Y) distance from Ground rod under test (X) FEET	Measured Resistance OHMS
100	_____	_____
90	_____	_____
80	_____	_____
70	_____	_____
60	_____	_____
50	_____	_____
40	_____	_____
30	_____	_____
20	_____	_____
10	_____	_____
0	_____	_____



Comments: _____

_____

_____

HIGH POTENTIAL TEST REPORT

Date:_____ Start Time:_____/ Stop Time:_____

Circuit Designation:_____

Circuit Designation:	Circuit Description:	Circuit Length:
Circuit Operating Voltage:	Circuit Isolation Transformers Qty/Size:	

Test Equipment:	Manufacturer	Model #	Serial #	Upper Range Limit:

Associated equipment included in test:

Circuit Continuity:	Test Voltage:	Cable Manufacturer:

VISUAL/MECHANICAL INSPECTION

CHECK POINT	*COND	NOTES	CHECK POINT	*COND	NOTES
GROUNDS PORPERLY TERMINATED			ACCEPTABLE BENDING RADIUS		
PHYSICAL DAMAGE			TIGHTNESS CABLE CONNECTION		

ELECTRICAL TESTS

MEGGER @ 2500 VDC (1 MINUTE) = > 50KMΩ

TEST VOLTAGE (KV)	LEAKAGE CURRENT (MICRO-AMPS)	TIME HELD AT TEST VOLTAGE (MINUTES)
2.5		1 MIN
5		1 MIN
7.5		1 MIN
10		1MIN
10		1 MIN
10		15 SEC
10		30 SEC
10		45 SEC
10		60 SEC
10		3 MIN
10		4 MIN
10		5 MIN
10		6 MIN
10		7 MIN
10		8 MIN
10		9 MIN
10		10 MIN

DECAYING VOLTAGE = @ 30 SECONDS= @ 1 MINUTE= KV

NOTES:

*CONDITION: A=ACCEPTABLE, R=NEEDS REPAIR/REPLACEMENT OR ADJUSTMEN, C=CORRECTED, NA=NOT APPLICABLE

RPR:_____ Witness:_____ Tested By:_____

Test sheet:_____

Cable _____Hi-Pot

		TIME																			
		1 min	1min	1 min	1 min	15 sec	30 sec	45 sec	60 sec	15 sec	30 sec	45 sec	60 sec	3 min	4 min	5 min	6 min	7 min	8 min	9 min	10 min
MICROAMPS	1.9																				
	1.8																				
	1.7																				
	1.6																				
	1.5																				
	1.4																				
	1.3																				
	1.2																				
	1.1																				
	1.0																				
	0.9																				
	0.8																				
	0.7																				
	0.6																				
	0.5																				
	0.4																				
	0.3																				
	0.2																				
	0.1																				
		2.5	5	7.5	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
		KV																			

Suggested Hi-Pot Test Process

1) Apply the DC Voltage up to the prescribed maximum test voltage of 10 kV in 4 Equal steps
2) Raise the voltage at an even rate obtain each required step in not less than 10 seconds
3) Hold the voltage at each step for 60 seconds.
4) Read and Record the leakage current at the end of each hold project.
5) Hold the maximum test voltage of 10kV for approximately 10 minutes
6) Read and record the leakage current at 15 second intervals during the first two minutes and then every minute thereafter for the remainder of the test.
7) Bring the test voltage control quickly and smoothly to zero
8) Discharge cable to EES with hot stick

Airfield Lighting Circuit Continuity and Insulation Resistance Testing

Date: _____ Start Time: _____ / Stop Time _____

Circuit Designation:	Circuit Description	Circuit Length
Circuit Operating Voltage	Circuit Isolation Transformers Qty/Size:	

Hazard Risk Evaluation Performed? Yes No

Ambient Temperature: _____ Relative Humidity: _____

Sky Conditions.: _____ Rain last 48hrs: _____

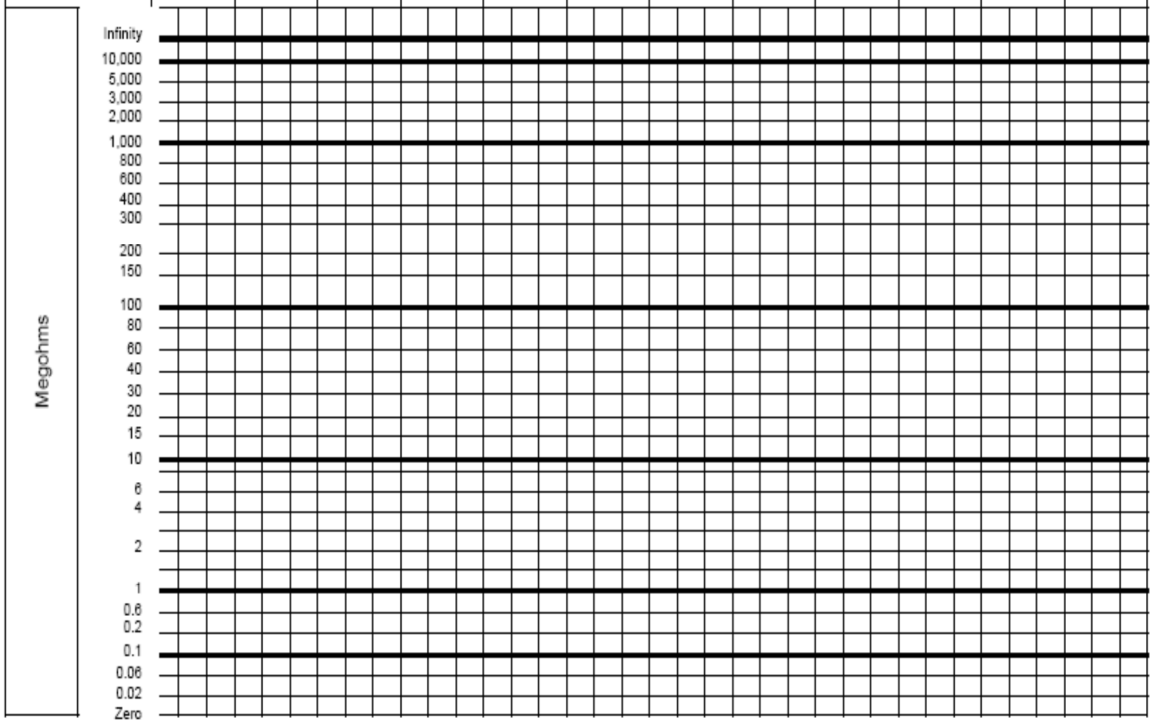
Test Equipment:	Manufacturer	Model #	Serial#	Upper Range Limit:

Associated Equipment included in test: _____

Circuit Continuity:	Test Voltage:	Cable Manufacturer:

Tested by: _____ Witness: _____

Minutes	0.25	0.5	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
Reading												
Correction												



Comments: _____

END OF ITEM L-130

Item 16 - Electrical Work – RWSL Shelter and FAA Facilities

16-1.1 General. This specification covers the minimum requirements for electrical work in the FAA RWSL shelters and immediate area and in the existing FAA facilities. Where the phrase "unless otherwise indicated" or similar wording appears, it refers exclusively to other documents that are specific parts of the contract.

16-1.2 Applicable documents. The current issues of the following documents in effect on the date of the Screening Information Request (SIR) form a part of this specification, and are applicable to the extent specified herein.

16-1.2.1 Federal specifications.

CC-M-1807	Motors, Alternating Current Fractional and Integral Horsepower (500 H.P. and smaller)
J-C-30	Cable and Wire, Electrical (Power, Fixed Installation)
W-B-30	Ballast, Fluorescent Lamp
W-C-375	Circuit Breakers, Molded Case; Branch Circuit and Service
W-C-582	Conduit, Raceway, Metal, and Fittings; Surface
W-C-586	Conduit Outlet Boxes, Bodies, and Entrance Caps, Electrical: Cast Metal-For Shore Use
W-C-1094	Conduit and Conduit Fittings; Plastic, Rigid
W-F-414	Fixture, Lighting (Fluorescent, Alternating Current, Pendant Mounting)
W-F-1662	Fixture, Lighting (Fluorescent, Alternating Current, Recessed and Surface Ceiling)
W-J-800	Junction Box; Extension, Junction Box: Cover, Junction Box
W-L-305	Light Set, General Illumination (Emergency or Auxiliary)
W-P-115	Panel, Power Distribution
W-S-610	Splice, Conductor
W-S-865	Switch, Box (Enclosed), Surface-Mounted
WW-C-540	Conduit, Metal, Rigid: and Coupling, Elbow, and Nipple, Electrical Conduit: Aluminum
WW-C-563	Conduit, Metal, Rigid: Electrical, Thin Wall Steel Type (Electrical Metallic Tubing); Straight Lengths, Elbows, and Bends
WW-C-566	Conduit, Metal, Flexible
WW-C-581	Conduit, Metal, Rigid; and Coupling, Elbow, and Nipple, Electrical Conduit: Zinc Coated
QQ-W-343	Wire, Electrical, (uninsulated)

16-1.2.2 Military specifications.

MIL-P-15147	Primer and Enamel, Coal Tar
MIL-R-21931	Resin, Epoxy

16-1.2.3 American National Standards Institute (ANSI).

ANSI C37.16	(1988; C37.16a) Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors Preferred Ratings, Related Requirements, and Application Recommendations
ANSI / E1A-310D	Cabinets, Racks, Panels and Associated Equipment

16-1.2.4 American Society For Testing And Materials (ASTM).

ASTM B 1	(1990) Hard-Drawn Copper Wire
ASTM B 8	(1993) Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft
ASTM D 709	(1992) Laminated Thermosetting Materials

16-1.2.5 Institute Of Electrical And Electronics RPRs (IEEE).

IEEE C2	(1997) National Electrical Safety Code
IEEE C37.13	(1990) Low-Voltage AC Power Circuit Breakers Used in Enclosures
IEEE C37.20.1	(1993) Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear
IEEE C57.12.	EEE Standard Terminology for Power and Distribution Transformers
IEEE C62.41	(1991) Surge Voltages in Low-Voltage AC Power Circuits
IEEE C95.1	(1991) Standard for Safety Levels with Respect to Radio Frequency Electromagnetic Fields

16-1.2.6 National Fire Protection Association (NFPA) Publications.

No. 70	National Electric Code (NEC)
No. 70E	Standard for Electrical Safety in the Work Place
No. 780	Lightning Protection Code

16-1.2.7 National Electrical Manufacturers Association (NEMA) Standards.

NEMA OS 1	(1989) Sheet Steel Outlet Boxes, Device Boxes, Covers, and Box Supports
NEMA PB 1	(1990) Panelboards
NEMA ST 20	Dry Type Transformers for General Applications
NEMA VE 1	(1991) Metallic Cable Tray Systems
NEMA WC 5	The Moplastic Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
NEMA WD 1	(1983; R1989) General Requirements for Wiring Devices
NEMA WD 1	(2002) Wiring Devices Dimensional Requirements

16-1.2.8 Underwriters' Laboratories, Inc. (UL) Standards.

UL 50	(1995) Enclosures for Electrical Equipment
UL 96A	Installation Requirements for Lightning Protection Systems
UL 870	Wireways, Auxiliary Gutters and Associated Fittings

16-1.2.9 Federal Aviation Administration Specification.

FAA-C-1217h	Electrical Work, Interior
FAA-C-1391e	Installation and Splicing of Underground Cables
FAA -E-2013c	Cable, Electrical Power, 600 to 15,000 volts.
FAA-STD-019g	Lightning Protection, Grounding, Bonding, and Shielding Requirements for Facilities and Electronic Equipment
FAA G 2100H	Electronic Equipment, General Requirements
ORDER 2072b	Cable, Telephone, Exterior
ORDER 6950.22	Maintenance of Electrical Power and Control Cables

16-1.2.10 Other documents. Requirements based upon manufacturers technical documents.

16-1.2.10.1 Local utility companies. The rules and regulations of the Local Utility Companies providing service.

16-1.2.10.2 Local governing bodies. The rules, regulations, and codes of local governing bodies.

(Copies of Federal Specifications and Military specifications may be obtained from General Services Administration offices in Washington, D.C., Seattle, San Francisco, Denver, Kansas City, Mo., Chicago, Atlanta, New York, Boston, Dallas, and Los Angeles.)

(Requests for copies of the NFPA Publications may be obtained from the National Fire Protection Association, Battery-March Park, Quincy, MA 02269).

(Requests for copies of NEMA standards may be obtained from National Electrical Manufacturers Association, 155 East 44th St., New York, NY 10017)

(Requests for copies of UL Standards may be obtained from Underwriters' Laboratories, Inc., Publications Department, 207 E. Ohio St., Chicago, IL 60611).

16-1.3 Materials. The Contractor shall furnish all materials not specifically identified as Government Furnished Materials (GFM) in the Contract documents or drawings. Materials and equipment, shall comply with all contract requirements. Materials furnished by the Contractor shall be new, the standard products of manufacturers regularly engaged in the production of such materials, and of the manufacturer's latest designs that comply with the specification requirements. If materials and equipment requirements conflict, the order of precedence for selection shall be as follows: any special contract provision, the contract drawings, this specification, and then in continuing order of precedence, referenced FAA specifications, Military Specifications, Federal Specifications, NFPA publications, IEEE standards, UL standards and NEMA standards. Wherever standards have been established by Underwriters' Laboratories, Inc., the material shall bear the UL label. The label or listing of the Underwriters' Laboratories, Inc., shall be accepted as evidence that the materials or equipment conform to the applicable standards of that agency. Items which are required to be listed and labeled in accordance with Underwriters' Laboratories must be affixed with a UL label that states that it is UL listed. No exceptions or waivers will be granted to this requirement.

16-1.4 Installation.

16-1.4.1 General. The rules, regulations and reference specifications enumerated herein shall be considered as minimum requirements and shall not relieve the Contractor from furnishing and installing higher grades of materials and workmanship than are specified herein or when so required by the contract drawings. This specification shall govern when conflicts occur between reference documents and this specification.

16-1.4.2 Workmanship. All materials and equipment shall be installed in accordance with the contract drawings and the recommendations of the manufacturer as approved by the RE. The installation shall be

accomplished by skilled workmen regularly engaged in this type of work. All cable connections and terminations shall be completed by a licensed electrician.

16-1.4.3 Contract drawings. Where the electrical drawings indicate (diagrammatically or otherwise) the work intended and the functions to be performed, even though some details are not shown, the Contractor shall furnish all equipment, material (other than Government furnished Materials, see paragraph 16-1.3), and labor to complete the installation work, and accomplish all the indicated functions of the electrical installation. Further, the Contractor shall be responsible for taking the necessary actions to ensure that all electrical work is coordinated and compatible with architectural, mechanical and structural plans and the layout of any special electronic equipment.

16-1.4.3.1 Minor departures. Minor departures may be permitted from exact dimensions shown in electrical plans, that are required to avoid conflict or unnecessary difficulty in placement of a dimensioned item, provided all contract requirements are met shall be coordinated with the RE. The Contractor shall promptly obtain approval from the Resident RPR prior to undertaking any such proposed departure.

16-1.4.4 Grounding.

16-1.4.4.1 General. The grounding system for the facility shall be as indicated on the contract drawings and as specified herein. Where the Federal requirements are more stringent than the National Electrical Code, FAA-STD-019g Paragraphs 4.4 and 4.7 and FAA-C-1217h shall govern. The most recent NEC shall also be observed and in no case, be violated.

16-1.4.4.2 Grounding electrode conductor. The grounding electrode conductor shall be copper, insulated green, stranded, and shall be sized as shown on the contract documents. When not indicated in the contract documents, the conductor shall be copper and sized in accordance with Table 250-66 of the NEC, entitled "Grounding Electrode conductor for AC systems". Except that the conductor shall not be sized smaller than #6 AWG. This conductor shall be connected to the neutral bus in the service disconnecting means, extend directly to the ground rod or Earth Electrode System (EES), otherwise known as a counterpoise system, in the grounding electrode system, and in one continuous unspliced run. Where the grounding electrode conductor is routed through a metal raceway, the raceway shall be electrically continuous and bonded to the conductor at each end. The conductor shall be protected from physical damage in accordance with the NEC.

16-1.4.4.3 Earth electrode system. The earth electrode system shall be installed as shown in the contract documents. Unless otherwise indicated in these documents, the earth electrode system shall consist of a minimum of four (4) ground rods located at the corners of the structure unless otherwise shown on the contract documents. Ground rods shall be located 2-6 ft. outside of foundation footings or overhangs of the structure. Rods shall be spaced apart a distance equal to or greater than the length of the rods. Ground rods shall be 3/4-inch by a minimum of 10 feet long copper or copper-clad steel. Sectionalized type or exothermic welded rods shall be used when deeper earth penetration is required. Rods shall be interconnected by a bare copper counterpoise cable forming a closed loop around a structure. The counterpoise cable shall be a minimum #4/0 AWG and shall be buried a minimum of 2 feet below grade. The top of the vertically driven ground rods shall be a minimum of 12 inches below grade. All underground metal conduits shall be connected to the earth electrode system by a copper cable no smaller than a #2 AWG. All underground connections shall be made by exothermic welding process.

16-1.4.4.4 Earth electrode system resistance. The resistance of the grounding electrode shall not exceed 10 ohms, as tested per paragraph 16-1.5.3.6 of this document, unless otherwise indicated.

16-1.4.4.5 Equipment grounding conductor.

16-1.4.4.5.1 Size. The equipment grounding conductor shall be a green insulated copper conductor unless otherwise indicated. When this conductor is not sized, or shown on the drawings, it shall be sized in

accordance with Table 250-122 of the NEC, entitled "Minimum Size Equipment Grounding Conductor for Grounding Raceway and Equipment". In no case shall it be smaller than #12 AWG.

16-1.4.4.5.2 Connections. The equipment grounding conductor shall be installed in the same conduit as its related branch or feeder circuit and shall be connected to the ground bus in the branch or distribution panel board. The equipment grounding conductor shall be connected to the grounded conductor (neutral) only at the main service disconnect means. A dedicated grounding conductor shall be installed for each circuit.

16-1.4.4.5.3 Installations. Where parallel feeders are installed in more than one raceway, a full sized equipment grounding conductor shall be installed in each raceway. The metallic conduit housing the equipment grounding conductor shall be electrically continuous forming a parallel path to the equipment grounding conductor. Under no circumstances shall the equipment grounding conductor be omitted from the electrical circuit, nor shall any separate grounding system such as the signal ground (Multipoint, Singlepoint, etc.) be used for an alternating grounding system (AC) or an alternate path to the grounding electrode. All connections to the equipment to be grounded shall be made with a ground connector specifically intended for that purpose. Bare wire wrapped around connecting screws or mounting bolts and screws is not acceptable for use as a grounding connection. All ground lugs shall be of a non corrosive material suitable for use as a grounding connection, and must be compatible with the type of metal being grounded. Ground lugs shall be mounted on a clean, bare, metal surface that is free of paint, rust, etc.

All metallic non-current carrying parts of electrical equipment shall be grounded with an equipment grounding conductor whether or not shown on the drawings.

16-1.4.4.6 Raceway grounding. Insulated copper bonding jumpers shall be installed between adjacent raceway sections to assure proper bonding. When installing cable trays and wireway, see FAA-STD-019g, Paragraph 4.7.4.2. Unless otherwise indicated, the minimum size ground conductor shall be #6 AWG, insulated green with an orange tracer. Where aluminum raceways are used, the #6 AWG conductor shall be bonded with approved connectors for the dissimilar metals.

16-1.4.4.7 Other grounding systems. Any additional grounding systems used for electronic equipment shall be connected directly to the exterior Earth Electrode System (EES) unless otherwise indicated on the drawings. Other grounding systems shall not be used in place of the equipment grounding conductor system.

The conductors used for other grounding systems shall be color coded green with a bright yellow stripe for single point (isolated) signal ground, a green with a bright orange stripe for multipoint signal ground, and green with a bright red stripe for high energy transient ground. The multipoint and singlepoint grounding systems shall have their respective grounding plate. Where both types of plates are called out an additional plate referred to as the main ground plate, shall interconnect the two and both connect to the EES. If only the multipoint plate is called out, it shall interconnect the interior connections to the EES. Any cable connections to the ground plates shall be as direct as possible without any sharp bends, loops, or kinks.

All cable trays shall be bonded to the MPG system within 2' of each end of the run and at intervals not to exceed 50'. The resistance of each of the connections shall not exceed 5 milliohms. The minimum size bonding conductor for connection of a cable tray to the MPG shall be #2 AWG copper conductor.

All separately derived systems are to be grounded directly to the EES. The grounding electrode conductor shall be copper and sized in accordance with NEC requirements, except that it shall not be smaller than a #2 AWG conductor.

16-1.4.5 Lightning protection.

16-1.4.5.1 General. Lightning protection systems, where shown on the contract drawings, shall be in accordance with the applicable parts of NFPA 780 and shall be installed to meet the installation requirements of UL 96A. Materials used in lightning protection systems shall be of a type specifically manufactured for such use as described in UL 96A and NFPA No. 780, Table 4.1.1.1.2, Minimum Class II

Material Requirements. All conductors used in the lightning protection system shall be Class II main sized conductors. Down conductors must not run with or adjacent to signal or power conductors. If signal or power conductors must be installed within 6 feet of lightning protection conductors, as measured by the most direct path, i.e. through walls, these conductors shall be installed in heavy wall rigid steel conduit, maintaining maximum separation. Shop drawings, prepared by the Contractor for installation of the system showing the manufacturer's catalog number and the exact location of each item of the lightning protection system shall be submitted to the RPR for approval in accordance with paragraph 16-1.5.2.

16-1.4.5.2 Connections below grade. All underground connections of a lightning protection system down conductors, shall terminate at ground rods in the grounding electrode system with exothermic welds.

16-1.4.5.3 Transient protection. The "A" Bus (High Energy Transient ground bus) for transient protection devices shall be connected directly to the grounding electrode system using the most direct path and without loops, sharp bends, or kinks. Government furnished transient suppressors shall utilize the maximum wire size allowed by the terminating lug. In no case shall it be smaller than a #4/0 AWG. The conductor shall be stranded, copper, color coded green with a red tracer.

16-1.4.5.4 AC surge arresters. The AC surge arrester is connected to the load side (output power) of the safety disconnect switch using the most direct path. It shall be installed within 12 inches of the service entrance disconnecting means. No sharp bends, kinks, or loops are allowed. There shall be no interconnection between neutral and ground within the arrester. Arrestor conductors shall be stranded copper type THHN #4/0 AWG, and 1-#4/0 AWG green insulated ground, unless a smaller size is recommended by the arrester manufacturer’s technical documentation.

Surge arresters shall meet the requirements of IEEE C62.41 and be UL listed and labeled as having been tested in accordance with UL 1449 (Second Edition). Surge suppressors ratings shall be 277v RMS line to neutral and 480v RMS line to line. Operating voltage 60HZ., 3-phase, 4 wire with ground. Surge arrester voltage (maximum operating voltage) shall be 350v RMS. The arrestor shall be internally fusible to provide short circuit protection, and shall have an indicator light to monitor arrestor conditions unless provided otherwise by the FAA.

16-1.4.6 Wiring methods.

16-1.4.6.1 General. Unless otherwise indicated, wiring shall consist of insulated copper conductors installed in conduit. In single phase (120 volt, two wire and 120/240 volt 3-wire), one grounded conductor (neutral) shall accompany each ungrounded phase conductor (120 volt system) or ungrounded phase conductor pair (120/240 volt system) powered from a circuit interrupting device. In three-phase, wye, 4-wire systems, one grounded conductor (neutral) shall accompany the three related ungrounded conductors fed from a circuit interrupting device. All neutral conductors shall extend from the neutral bus in the device where the active conductors originate. In, addition, one equipment grounding conductor shall accompany each AC circuit (120, 120/240, etc.). Device terminals for connection of more than one conductor shall be specifically designed for that purpose.

All cable shields (including coaxial) shall be grounded at each end.

16-1.4.6.2 Raceway system. Minimum conduit or tubing size shall be 3/4" unless otherwise specified. Each run shall be complete, and shall be fished and swabbed before conductors are installed. Ends of conduit systems not terminated in boxes or cabinets shall be capped. Exposed raceways shall be installed parallel to or at right angles with the lines of the structure. Crushed or deformed raceways shall not be installed. A pull wire shall be installed in all empty tubing and conduit systems in which wiring is to be installed by others. The pull wire shall be a minimum 200 pound tensile strength polypropylene rope. Ten inches of slack shall be left at each end of the pull wire. Sections of raceways which pass through to underground locations shall be of a type allowed for such locations by the NEC, and shall extend a minimum of 12 inches above the underground area. Where conduit has to be cut in the field, it shall be cut square using a hand or power hacksaw or approved pipe cutter using cutting knives. The cut ends of the field-cut

conduit shall be reamed to remove burrs and sharp edges. Where threads have to be cut on conduit, the threads shall have the same effective length and shall have the same thread dimensions and taper as specified for factory cut threads on conduit. Conduits installed with threads not complying with these requirements shall be removed and replaced with conduits which comply. Exposed threads of all conduit or tubing shall be covered to prevent damage to cables, using an approved conduit bushing. Where conduits penetrate walls or floors separating interior from exterior, they shall be sealed to prevent moisture and rodent entry and to deter air transfer. Sealing methods and sealants shall be in accordance with the NEC. Openings around penetrations through fire-resistant-rated walls, partitions, floors, or ceilings shall be fire stopped using approved methods to maintain the fire resistance rating.

16-1.4.6.2.1 Heavy wall galvanized rigid steel (RGS) conduit. Heavy wall galvanized rigid steel conduit shall conform to Federal Spec. WW-C-581. Rigid steel conduit may be used in all locations. For installation below slab, on grade, or underground, the conduit shall be factory coated with either .008 inch of epoxy resin per Spec MIL-R-21931, .020 inch of polyvinyl chloride or .063 inch of coal tar enamel per Spec. MIL-P-15147. Fittings used underground shall be protected by field wrapping, 0.01-inch thick pipe wrapping plastic tape applied with 50% overlap. All fittings used with rigid steel conduit shall be of the threaded type of the same material as the conduit. Where conduits enter enclosures without threaded hubs, double locknuts (one on each side of the enclosure wall) shall be used to securely bond the conduit to the enclosure. In addition, a metallic insulated bushing shall be installed on the interior threaded end of the conduit to protect conductor insulation.

16-1.4.6.2.2 Electrical metallic tubing (EMT). EMT shall conform to Federal Spec. WW-C-563. EMT may be used only in dry interior locations, and where not subject to physical damage. EMT shall not be used on circuits above 600 volts or in sizes greater than 3 inches in diameter. Fittings used with EMT shall be standard compression type fittings designed for this type of conduit unless otherwise indicated. Screw type fittings are not acceptable. Where conduits enter enclosures without threaded hubs, an appropriate connector with threads and locknut shall be used to securely bond the conduit to the enclosure. The connector body and locknut shall be installed so that firm contact is made on each side of the enclosure. In addition, the connectors shall be insulated throat type. Where box fittings are used with only a locknut, a smooth bushing shall be installed on the fitting end.

16-1.4.6.2.3 Intermediate metal conduit (IMC). Not acceptable for usage.

16-1.4.6.2.4 Rigid aluminum conduit. Not acceptable for usage.

16-1.4.6.2.5 Rigid plastic conduit. Rigid plastic conduit shall be heavy wall PVC conforming to Federal Spec. W-C-1094, Type II. Rigid plastic conduit used to protect electrical power conductors may only be used underground, or in concrete, or as a vertical riser up to 6 inches above grade or floor surface for connection to metal conduit; and only when required by the contract drawings or specific job specifications. PVC fittings shall be used with PVC conduit and shall be assembled in accordance with manufacturer's instructions. A PVC threaded fitting with locknut and plastic bushing shall be used to connect PVC conduit to boxes or cabinets without threaded hubs. Rigid plastic conduit may be used to protect lightning protection system conductors, and in interior locations, to protect grounding conductors. In areas subject to physical damage, schedule 80 PVC is required.

16-1.4.6.2.6 Liquidtight flexible steel conduit. Liquidtight flexible steel conduit shall conform to Federal Spec. WW-C-566. Liquidtight flexible steel conduit shall be limited to a maximum length of 6 ft., as permitted by the NEC.

16-1.4.6.2.7 Surface metal raceways. Not acceptable for usage.

16-1.4.6.2.8 Square duct. Square duct shall conform to UL Standard 870. Square duct shall only be installed in exposed locations. All square duct joining hardware shall be utilized to ensure proper assembly of adjacent sections. Also see paragraph 16-1.4.4.6 for bonding requirements.

16-1.4.6.2.9 Cable rack systems.

16-1.4.6.2.9.1 General. Cable rack systems shall be of the ladder or ventilated trough type conforming to NEMA Standard VE 1, unless otherwise indicated. All components for each cable rack system shall be the product of a single manufacturer. Cable rack support spacing shall be as recommended by the manufacturer except that in no case shall spacing of supports exceed 6 feet. Fittings shall have not less than the load-carrying capability of straight tray sections and shall have manufacturer's minimum standard radius. Also see paragraph 16-1.4.4.6 for bonding requirements.

16-1.4.6.2.9.2 Dimensions. The straight sections, bends, tees, offsets, reducers, etc., for the ladder type cable rack system shall consist of 3-inch minimum side channels with suitable cross channels (rungs) installed on 6-inch centers unless otherwise indicated. The straight sections, fittings, etc., for the ventilated type cable rack system shall consist of 3-inch minimum high sides and a ventilated bottom with cross pieces 2-inches (maximum) wide and 3-inch (maximum) centers and openings 2-inches (maximum) wide. The cable rack widths shall be as shown on the drawings.

16-1.4.6.3 Raceway support systems.

16-1.4.6.3.1 General. Raceways shall be securely supported at intervals specified in NEC and fastened in place with pipe straps, wall brackets, hangers, or ceiling trapezes. Fastenings shall be by wood screws, nails or screw type nails; by toggle bolts on hollow masonry units; by expansion-bolts on concrete or brick; by machine screws, welded threaded studs, or spring tension clamps on steel work. Nail type nylon anchors or threaded studs driven in by a power charge and provided with lock washers and nuts may be used in lieu of expansion bolts or machine screws. Threaded C clamps with retainers may be used. Raceways or pipe straps shall not be welded to steel structures. Holes cut to a depth of more than 1 1/2 inch in reinforced concrete beams, or to a depth of more than 3/4 inch in reinforced concrete joists, shall not cut the main reinforcing bars. Holes not used shall be filled. In partitions of light steel construction, sheet metal screws may be used.

Raceways shall not be supported from sheet metal roof decks. In suspended ceiling construction, raceways shall not be fastened to the suspended ceiling supports.

16-1.4.6.3.2 Signal raceways. Signal system raceways shall be installed in accordance with the previous requirements for conduit and tubing and with the additional requirements that no length of run shall exceed 50 feet for 3/4 inch sizes, 100 feet for 1 inch or larger sizes, and shall not contain more than two 90 degree bends or the equivalent. Pull or junction boxes shall be installed to comply with these limitations, whether or not indicated on the drawings. Bends in conduit, 1 inch and larger shall have minimum inside radii of 12 times the nominal conduit diameter.

16-1.4.6.4 Conductors.

16-1.4.6.4.1 Uninsulated conductors. Uninsulated conductors shall be copper in accordance with Federal Specification QQ-W-343.

16-1.4.6.4.2 Insulated conductors. Unless otherwise indicated, insulated conductors shall be copper with thermoplastic or thermosetting insulation, type THHW or type THHN, all insulated for 600V in accordance with Federal Specification J-C-30. Unless otherwise indicated, conductors #8 AWG and larger shall be stranded. Minimum branch circuit conductor size shall be #12 AWG. Minimum control wire size for alternating current circuits shall be #14 AWG, unless noted otherwise.

16-1.4.6.4.2.1 Fixture wiring. Fixture wiring shall be thermoplastic insulated copper, and rated for 600 volts, in accordance with Federal Spec. J-C-30 and the NEC.

16-1.4.6.4.2.2 Color coding. All feeder and branch circuits, including neutral conductors, shall be identified at both ends of the conductor with panel and circuit number indicated. This shall be accomplished using shrink-embossed labels only. Feeder conductors to panels and to 3-phase circuits shall be color coded as specified hereinafter. Single-phase branch circuits may be color coded in a like manner. The color coding

shall be continuous throughout the facility on each phase conductor to its point of utilization so that the conductor phase connection is readily identifiable. The equipment grounding conductor shall be color coded green as described in paragraph 16-1.4.4.5. Conductors color-coded green insulation with yellow, orange or red tracers shall be used for other grounding systems, as described in paragraph 16-1.4.4.7. Neutral conductors shall be continuous white or gray unless more than one voltage system is run in the same raceway, box, or other type enclosure. The neutral of the other systems shall be white or gray with identifiable colored tracers (not green). For conductors, #4 AWG and larger, where color coding is not available, color coded tape, half lapped for a minimum length of 3 inches, shall be used. In no case, shall green insulated conductors be re-identified for purposes other than grounding, nor shall white or neutral grey conductors be re-identified as other than grounded (neutral) conductors.

Where conductors are color coded in this manner, they shall be color coded in all junction boxes, pull boxes, accessible raceways, panelboards, outlets, and switches, as well as at all terminations. Conductors in accessible raceways shall be coded in such manner that by removing or opening any cover, the coding will be visible.

Phase conductors shall be color coded as follows:

Single Phase		**Three Phase**	
120 V	**120/208 (240) V**	**120/208 or 240 V**	**277/480 V**
Line - Black	Line 1 - Black	Phase A - Black	Phase A - Brown
	Line 2 - Red	Phase B - Red	Phase B - Orange
Neut.- White	Neut.- White	Phase C - Blue	Phase C - Yellow
		Neut.- Gray/White	Neut.- Gray/White

Color coding for conductors in control cables shall be in accordance with NEMA Standard WC-5. DC power conductors shall be color coded as follows:

Positive (+) conductor - Red with brown tracer.

Negative (-) conductor - Brown with red tracer.

Unless otherwise noted in equipment specifications

16-1.4.6.4.3 Splices. Splices shall be made only at outlets, junction boxes, or accessible raceways. Splices shall be made with solderless connectors conforming to Federal Specification W-S-610. Wire nuts may be used to splice conductors sized #10 AWG and smaller. Compression connectors shall be used to splice conductors #8 AWG and larger. All splices shall be insulated with electrical insulating tape or heat shrink tubing, in a manner, which shall make their insulation equal to the insulation level of factory installed the conductors. Interconnections between aluminum and copper conductors shall be made only with materials approved for this purpose in accordance with the applicable portions of the NEC and with devices approved for this purpose by UL. Wire nuts shall only be used for interior applications within covered junction boxes. All crimped connections of cable conductors which are #6 AWG or larger shall be accomplished hydraulically using a minimum force of 12 tons concentrically applied. Plier type installation tools are not permissible.

16-1.4.7 Boxes. Boxes shall be one piece galvanized steel conforming to Federal Spec. W-J-800, cast-metal threaded-hub type conforming to UL 514A and UL514B or metal outlet boxes conforming to NEMA OS 1. Where not sized on the drawings, boxes shall be sized in accordance with the NEC. Where called out

on drawings, the drawing material specifications shall govern. Exterior boxes shall be NEMA Type 3R, 4, 12 or 13 as identified on the drawings.

16-1.4.7.1 Applications. Boxes shall be provided in the wiring or raceway system for pulling wires, making connections, and mounting devices or fixtures. On exterior surfaces and in wet locations, boxes for metal raceways shall be of the cast-metal threaded-hub type. In hazardous areas, boxes shall be explosion proof. Boxes in other locations shall be cast metal threaded-hub type or one piece galvanized steel with covers designed for surface installation. Non-metallic boxes may be used with non-metallic raceway systems only. Each box shall have the volume required by the NEC for the number and size of conductors in the box. Each outlet box shall have a machine screw which fits into a tapped hole in the box for the ground connection. Boxes for mounting lighting fixtures shall be not less than 4 inches square. Boxes installed for concealed wiring shall be provided with extension rings or plaster covers. The front edge of the box shall be flush or recessed not more than 1/4 inch from the finished wall surface (whether the finished surface is drywall, or drywall and a sound absorbing material). Boxes for use in masonry-block or tile walls shall be -cornered tile-type, or standard boxes having square-cornered tile-type covers. Cast metal boxes installed in wet locations and boxes installed flush with the exterior surfaces shall be gasketed. Separate boxes shall be provided for flush or recessed fixtures where required by the fixture terminal operating temperature, and fixtures shall be readily removable for access to the boxes unless ceiling access panels are provided. Boxes for fixtures on suspended ceilings shall be supported independently of the ceiling supports. Boxes shall not be supported from sheet metal roof decks.

16-1.4.7.2 Supports. Boxes and supports shall be fastened to wood with wood screws, nails, or screw type nails of equal holding strength, with bolts and expansion shields on concrete or brick, with toggle bolts on hollow masonry units, and with machine screws or welded studs on steel work. Threaded studs driven in by powder charge and provided with lockwashers and nuts, or nail type nylon anchors may be used in lieu of expansion shields, or machine screws. In open overhead spaces, cast metal boxes threaded to raceways need not be separately supported except where used for fixture support; cast metal boxes having threadless connectors and sheet metal boxes shall be supported directly from the building structure or by bar hangers. Where bar hangers are used, the bar shall be attached to raceways on opposite sides of the box and the raceway shall be supported with an approved fastener not more than 24 inches from the box. Penetration shall be no more than 1-1/2 inches into reinforced-concrete beams nor more than 3/4 inch into reinforced-concrete joists. Main reinforcing steel shall not be cut.

16-1.4.8 Wiring devices.

16-1.4.8.1 Receptacles. Receptacles shall be of the voltage and current rating indicated on the drawings. All receptacles shall be "specification grade” in accordance with NEMA STD WD-1.

For all critical power circuits, the receptacles shall be twist lock type except where the receptacles are not subject to being kicked or bumped (e.g. receptacles inside an equipment rack).

Wiring terminals shall be of the screw-type. Receptacles with push in connectors or a combination of screw type and push-ins are not acceptable. Unless noted otherwise, receptacles shall be installed 12" above finished floor.

All receptacles, unless they are of the isolated-ground type, shall be grounded by the installation of a grounding pigtail from the receptacle grounding screw directly to the grounding lug on the outlet box where the green equipment grounding conductor is terminated. The equipment grounding conductor shall be installed with the receptacle power conductors and shall terminate at the ground bus in the electrical service panel.

16-1.4.8.1.1 Duplex receptacles. Unless otherwise indicated, general purpose duplex receptacles shall be ‘specification grade”, 20 ampere minimum rating, 125 volt, grounding type (NEMA 5-20R per NEMA standard WD-1) such as Hubbell #5262-I, Bryant #5262-I, Pass & Seymour #5262-I, or approved equal.

16-1.4.8.1.2 250 Volt receptacles. Unless otherwise indicated, 250 volt receptacles shall be "specification grade", 20 ampere minimum rating, grounding type (NEMA 6-20R per NEMA Standard WD-1) such as Hubbell #5462-I, Bryant #5462-1, Pass & Seymour #6800-I, or approved equal.

16-1.4.8.1.3 Ground fault circuit interrupting (GFCI) receptacles. GFCI receptacles shall be installed at all locations as required by NEC and in other locations as indicated on the drawings. GFCI receptacles shall be 20 ampere minimum rating, 125 volt, duplex, UL Group I, Class A, such as 3M/GFI 2701, Pass and Seymour #1591, Square D #GFR-115-1, or approved equal. All exterior GFCI receptacles shall be mounted in weatherproof cast outlet boxes with gasket and weatherproof cover.

16-1.4.8.1.4 Clock outlets. Not acceptable for usage.

16-1.4.8.1.5 Isolated ground pin receptacles. Not acceptable for usage

16-1.4.8.1.6 Plug-in strip outlets. Not acceptable for usage

16-1.4.8.2 Wall switches. Wall switches shall be "Specification grade", rated 120/277 volts and shall be fully rated 20 amps, AC only. Wiring terminals shall be of the screw type. Switches with push-in connections or a combination of screw-type and push-in connectors are not acceptable. Switches shall be equipped with grounding terminals. They shall be grounded with a green grounding pigtail connected from the switch grounding screw directly to the grounding lug on the outlet box where the green equipment grounding conductor is terminated. Switches shall be the quiet operating type. Not more than one switch shall be installed in a single gang position.

16-1.4.8.2.1 Single pole and three way switches. Single pole switches shall be similar to Hubbell #1221-I, Bryant #4901-I, Pass & Seymour #20ACl-I or approved equal. Three way switches shall be Hubbell #1223-I, Bryant #4903-I, Pass & Seymour #20AC3-I or approved equal.

16-1.4.8.3 Device plates. Plates of the one piece type shall be provided for all outlets and fittings to suit the devices installed. Plate screws shall be of metal with countersunk heads, in a color to match the finish of the plates. Device plates color shall be approved by the RE. Plates shall be installed with all four edges in continuous contact with finished wall surfaces without the use of mats or similar devices. Plaster fillings will not be permitted. Plates shall be installed with an alignment tolerance of 1/16 inch. The use of sectional type device plates will not be permitted. Plates installed in wet locations shall be gasketed. Device plates for communications outlets shall have a 3/8 inch bushed opening in center or dome shaped grommet on the side. Where required, device plates for communication may be more than one piece type.

16-1.4.8.4 Photoelectric control. Unless otherwise indicated, photo-electric control for floodlighting or obstruction lighting shall be 120 volt, 3000 watt, single pole, single throw, double break, Sigma Instruments, Inc., Fisher Pierce #63305 DA or approved equal. Photoelectric control shall be mounted in weatherproof watt hour meter socket, and shall be installed on the building exterior, faced in a northerly direction.

16-1.4.8.5 Time switches. Not acceptable for usage

16-1.4.9 Service equipment.

16-1.4.9.1 Power. Service entrance equipment for power shall be in accordance with the regulations of the local utility providing service, the NEC, and FAA regulations.

16-1.4.9.1.1 Service entrance conduits. Service entrance conduits shall be installed as shown on the drawings and shall be heavy wall galvanized rigid steel unless otherwise indicated. Grounding bushings shall be installed on the ends of all service entrance conduits. Expansion couplings shall also be used if necessary. Refer to specification FAA-C-1391e for installation of underground cables.

16-1.4.9.1.1.1 Underground service. Underground service entrance conduits shall be installed a minimum of 2 feet below finished grade. Underground conduits, except where otherwise indicated, shall terminate at least 5 feet beyond the earth electrode system. All empty conduits shall be capped at both ends. Service

entrance conduit shall be electrically continuous between the service disconnecting means and the transformer housing. Service entrance conductors shall in no case be smaller than a #6 AWG copper conductor, per NEC article 230-202a or as shown on drawings.

16-1.4.9.1.1.2 Aerial service. Not applicable for usage.

16-1.4.9.1.2 Service disconnect means. Service equipment shall be a fused disconnect switch, a separately mounted circuit breaker or a main circuit breaker in the main distribution panel. Device terminals for connection of more than one conductor shall be specifically designed for that purpose. Proper lug coordination shall be used to ensure proper installation of the service feeders and the surge protection device. All switches and circuit breakers used for service entrance disconnecting means shall be UL approved for use as service equipment. See also paragraph 16-1.4.10.3 on circuit breakers.

16-1.4.9.1.3 AC power surge protection. An AC power surge arrester shall be installed as close as possible to (within 12 inches) of the safety disconnect switch. This arrester shall be compatible with the voltage of the service, and shall be wired in such manner that loops, sharp bends and kinks are avoided and all bends kept to a minimum. The arrester conductors shall be #4/0 AWG and #4/0 AWG ground insulated copper or larger unless a smaller size is recommended by the manufacturer. The surge arrester shall be wired to the line side of the safety disconnect switch.

16-1.4.9.2 Signal and communications.

16-1.4.9.2.1 Entrance conduits. Conduit materials shall be galvanized rigid steel unless otherwise indicated. Except where otherwise indicated, underground conduits shall be a minimum of 2 feet below finished grade and extend at least 20 feet beyond the grounding electrode system. Expansion couplings shall be used if necessary. The exterior ends of conduits shall be bonded to the grounding electrode system with #2 AWG bare copper conductors by exothermic welds or FAA-approved pressure connectors.

16-1.4.9.2.2 Transient protection demarcation box for electronic landlines. When indicated on the drawings, a junction box shall be installed where the electronics landlines and/or conduits enter the facility. This box shall house the terminal points for "SC" type connectors for use with fiber optic cables as indicated on the contract drawings. The box shall be NEMA 1, either galvanized or factory painted, and sized as shown on the drawings.

16-1.4.10 Panel boards.

16-1.4.10.1 General. Panelboards shall be circuit-breaker-equipped, dead-front type, shall conform to Federal Specification W-P-115 Type 1, Class 1, and shall be listed by UL except for installations which require special panel boards to incorporate items not available as UL listed. Panel boards shall be mounted so that the height to the top of the panel board shall not exceed 81" above the finished floor level. All panel boards shall have a piano hinged door-in-door cover unless otherwise specified. All door hinges shall be concealed. Door shall have flush type cylinder lock and catch. Doors over 48 inches in height shall have auxiliary fasteners on top and bottom. All locks in a project shall be keyed alike, and 2 keys shall be furnished with each lock. Directories shall be typed to indicate the load served by each circuit and shall be mounted in a holder with a protective covering. The directory shall be arranged so that the typed entries simulate the circuit breaker positions in the panel board.

16-1.4.10.2 Wiring gutters. The minimum size of side wiring gutters shall be as follows:

A. 4" for mains up to and including 100 amp,

B. 6" for mains over 100 amp and up to 225 amp

C. 8" for mains over 225 amp and up to 600 amp

16-1.4.10.3 Circuit breakers. All circuit breakers shall be the quick-make, quick-break bolt on, thermal magnetic type, shall conform to Federal Specification W-C-375, and shall be UL listed. Circuit breakers shall have trip ratings, voltage ratings, and number of poles as defined on the drawings. Circuit breakers shall be rated for the voltage of the circuit on which they are used, and shall have a minimum interrupting rating of 10,000 amperes, symmetrical for branch breakers, and 22,000 amperes, symmetrical for main breakers.

All circuit breakers shall have a trip indicating feature. Single pole breakers shall be a full size module, two and three pole breakers shall be sized in even multiples of a single pole breaker. Breakers shall be sized so that two single pole breakers shall not be capable of fitting in a single housing. Multi-pole circuit breakers shall have an internal common trip mechanism. Devices with an adjustable magnetic trip shall be factory set to the "low" value. All circuit breakers and the panel boards in which the breakers are installed shall be made by the same manufacturer.

16-1.4.10.4 Fuses. A complete set of fuses shall be installed and one set of spares shall be furnished for each fusible device. Time/current tripping characteristics of fuses serving motors or connected in series with circuit breakers shall be coordinated for proper operation. Fuses shall have a voltage rating not less than the circuit voltage. Fuses shall have an interrupting rating as indicated, but if not indicated shall be not less than 100,000 amps when used in branch and distribution circuits, and not less than 200,000 amps when used in a service entrance switch.

16-1.4.10.5 Bus bars. Buses shall be copper. Bus capacity shall be as indicated on the drawings. Where bus capacity is not indicated on the drawings, the capacity shall be equal to or greater than the panel board feeder overcurrent protective device. Circuit breaker current-carrying connections to bus shall be of the bolted type. Stab-in types are not acceptable. Bus bar connections to branch circuit breakers shall be of the sequence phase type. The branch circuits shall be connected to the individual circuit breakers as indicated on the drawings. Where "provisions for", "future", or "space" is noted on the drawings, the panel board shall be equipped with bus connections for future installation of a breaker.

16-1.4.10.6 Neutral busses. The neutral bus shall be insulated from all panel boards except where the main panel board is used as a service disconnect means. All panel boards shall have an uninsulated ground bus bolted to the cabinet, adequate in size to accommodate the panel board capacity. The ground bus shall be isolated from the neutral bus except at the service disconnect means.

16-1.4.11 Self enclosed circuit breakers.

16-1.4.11.1 General. Self enclosed circuit breakers shall be UL listed thermal magnetic type or electronic solid state type and be mounted in NEMA type 1 enclosures with interrupting rating, trip rating, voltage rating and number of poles as indicated on the drawings unless otherwise specified. In no case shall the interrupting rating be less than 10,000 amperes symmetrical when used as branch circuit protection nor less than 18,000 amperes symmetrical when used as a main breaker, or service entrance disconnect means. Circuit breakers shall comply with Federal Specification W-C-375.

16-1.4.11.2 Requirements. Circuit breakers shall be of the molded-case type, shall have a quick-make and quick-break toggle mechanism, inverse-time trip characteristics and shall be trip-free on overload or short-circuit. Automatic release shall be secured by a bi-metallic thermal element releasing the mechanism latch.

In addition, a magnetic armature shall be provided to trip the breaker instantaneously for short-circuit currents above the overload range. Automatic tripping shall be indicated by a handle position between the manual Off and On positions.

16-1.4.12 Safety switches. Safety switches shall conform to Federal Specification W-S-865, and shall be type "HD", heavy duty, locking type, unless otherwise indicated. Switches mounted in dry locations shall be in NEMA 2 or greater enclosures. Switches installed outdoors, or in damp or locations shall be mounted in NEMA 3R enclosures. Switches shall be of the voltage and current ratings indicated on the drawings,

and each shall be capable of interrupting the locked rotor current of the motor for which it is to be used. The locked rotor current will be assumed to be ten (10) times the full rated load current. The switches shall be of the quick-make, quick-break type. Except for ground lugs which shall be bonded to the housing, all parts shall be mounted on insulating bases to permit replacement of any part from the front of the switch. All current-carrying parts shall be of high-conductivity copper, unless otherwise specified, and shall be designed to carry rated load without excessive heating. Switch contacts shall be silver-tungsten type or plated to minimize corrosion, pitting and oxidation and to assure suitable conductivity.

16-1.4.13 Cabinets. Signal systems cabinets shall be constructed of code gauge Zinc coated sheet steel, and shall meet the requirements of UL Standard 50. Cabinets shall be constructed with interior dimensions not less than those indicated on the drawings. Cabinets shall be mounted so that the height to the top of the cabinet does not exceed, 81" above finished floor level. A locking catch and two keys shall be provided with each cabinet unless otherwise indicated.

16-1.4.14 Motors and controls.

16-1.4.14.1 Motors. Motors furnished under this specification shall be of sufficient size for the duty to be performed, and shall not exceed the full-load rating when the driven equipment is operating at specified capacity. Motors shall be rated for the voltage of the system to which they are to be connected. Unless otherwise indicated, all motors shall have open frames, and continuous-duty classifications. Polyphase motors shall conform to Federal Specification CC-M-1807, and shall be Type II, Class 3, minimum insulation Class B, squirrel-cage type, having normal starting-torque and low-starting-current characteristics, unless otherwise specified. The horsepower ratings indicated on electrical plans are for guidance only and do not limit the equipment size. Higher ratings may be required to adequately power, driven equipment that has been selected by the site Contractor. At no time is the NEC to be violated.

16-1.4.14.2 Motor controls. Each motor, 1/8 horsepower or larger, shall have overload protection in each phase, or other equally rated method in accordance with the NEC.

The overload-protection device shall be provided either integral with the motor (except that motors to be installed in locations that are not readily accessible shall have the overload protection device located for easy access to the reset button), or with the control, or shall be mounted in a separate enclosure. Unless otherwise indicated, the protective device shall be of the manual reset type. Single or double pole tumbler switches specifically designed for alternating current (AC) operation may be used as manual controllers for single phase motors having a current rating not in excess of 80 percent of the switch rating. Automatic control devices such as a thermostat, float or pressure switches may control the starting and stopping of motors directly, provided the devices used are designed for that purpose and have an adequate horsepower rating. When the automatic control device operates the motor directly, a double-throw, three position tumbler or rotary switch shall be provided for manual control. When the automatic control device actuates the pilot control circuit of a magnetic starter, a three position selector switch marked Manual-Off-Automatic shall be provided. Connections to the selector switch shall be such that only the normal automatic regulatory control devices will be bypassed when the switch is in the manual position and all safety control devices, such as low or high-pressure cutouts, high-temperature cutouts, and motor-overload protective devices, shall be connected in the motor-control circuit in both the manual and the Automatic positions of the selector switch.

16-1.4.14.2.1 Reduced voltage controllers. Reduced voltage controllers shall be provided for polyphase motors when indicated on the drawings. Reduced-voltage starters shall be of the single-step autotransformer, reactor, or resistor type having an adjustable time interval between application of reduced and full voltages to the motors. Wye-Delta reduced voltage starters or partial winding increment starters having an adjustable time delay between application of voltage to the first and second winding of a motor may be used in lieu of the reduced voltage starters specified above for starting of motor-generator sets, centrifugally operated equipment or reciprocating compressors provided with automatic unloaders.

16-1.4.14.3 Motor disconnecting means. Each motor shall be provided with a disconnecting means and a manually operated switch as shown on the drawings or when required by the NEC. For single-phase motors, a single or double-pole toggle switch, rated only for alternating current (AC), will be acceptable for capacities less than 30 ampere, provided the ampere rating of the switch is at least 125% of the motor rating. Enclosed safety switches shall conform with paragraph 16-1.4.12 of this specification. Switches shall disconnect all ungrounded conductors.

16-1.4.15 Dry type transformers. Dry type transformers shall be of the sizes and characteristics shown on drawings. Unless otherwise indicated, the design, manufacture and testing of dry type transformers and the methods of conducting tests and preparing reports shall be in accordance with NEMA ST 20, and UL standards. Dry type transformers shall be self cooled (class AA) as defined by ANSI/IEEE C57.12.80. Unless otherwise indicated, minimum Basic Impulse Levels (BIL) shall be in accordance with IEEE STD 141.

16-1.4.15.1 Winding and taps. Dry type transformers shall be provided with separate primary and separate secondary windings for each phase. The transformer shall be provided with copper windings. Unless otherwise indicated, each primary winding of each transformer rated 15 KVA and greater shall be provided with four taps, two of which shall provide 2-1/2% increments above full rated voltage and two of which shall provide 2-1/2% increments below full rated voltage. Each primary winding of each transformer rated below 15 KVA shall be provided with not less than two taps, each providing a 5% increment below full rated voltage.

16-1.4.15.2 Insulation. Transformer having ratings not exceeding 25 KVA shall have 185º C insulation and shall be rated for continuous operation at rated KVA. Transformers having ratings exceeding 25 KVA shall have 220º C insulation and shall be rated for continuous operation at rated KVA.

16-1.4.15.3 Terminal compartments. Each dry type transformer shall be provided with a suitable terminal compartment to accommodate the required primary and secondary wiring connections, and side or bottom conduit entrance. Transformers having ratings not exceeding 25 KVA shall be provided with terminal leads equipped with factory installed and supported connectors. Transformers having ratings which exceed 25 KVA shall have terminal boards equipped with factory installed clamp type connectors. The terminal compartment temperature of the transformer shall not exceed 75° C when the transformer is operating continuously at rated load with an ambient temperature of 40° C.

16-1.4.15.4 Sound levels. Sound levels of dry type transformers, determined in accordance with NEMA Standard ST 20, shall not exceed the following:

Transformer Rating	Sound Level
Not over 9 KVA	40 db
Over 9 but not over 50 KVA	45 db
Over 50 but not over 150 KVA	50 db

All dry type transformers 45 KVA and greater shall have integral vibration isolation supports between the core and coil assembly and the transformer enclosure. Transformers of lesser rating shall have either integral or external vibration isolation supports. Conduit connections to transformers shall be made with flexible metal conduit, nominally 12" in length but not more than 36 inches in length.

16-1.4.15.5 Enclosures. Single phase transformers larger than 25 KVA and three-phase transformers-larger than 15 KVA shall be fully enclosed in steel enclosures. Transformers smaller than 15 KVA shall be fully encased in a steel enclosure with or without compound fill, or shall have exposed cores, impregnated windings, and steel enclosures encircling all live parts. Enclosures shall be bonded to the ground system in accordance with FAA-STD-019g. The surface temperature of the transformer shall not exceed 65º C when operating continuously at rated load with an ambient temperature of 40º C.

16-1.4.15.6 Mounting. Unless otherwise indicated on drawings, dry type transformers shall be floor mounted.

16-1.4.16 Identification. Major electronic/electrical components, motor controllers, panel boards, switches and self-enclosed circuit breakers shall be identified with a name plate which shows the functional name of the unit, voltage utilized, number of phases, and any other pertinent information. Switches for local lighting need not be identified.

16-1.4.16.1 Name plates. Name plates shall be non-ferrous metal or rigid plastic, stamped, embossed or engraved with red ⅜ inch minimum height lettering or numerals. The edges shall be chamfered. The plates shall be secured to the equipment with a minimum of two screws. When the nameplate is to be installed on an irregular-shaped object, the Contractor shall devise an approved support suitable for the application and ensure proper installation of the supports and nameplates. In all instances, the nameplate shall be installed in a conspicuous location. The equipment manufacturer's standard embossed nameplate material with black paint-filled letters may be furnished.

16-1.4.17 Lamps and lighting fixtures.

16-1.4.17.1 General. Lamps and lighting fixtures shall be of the types indicated on the drawings. All lighting fixtures shall be UL approved and shall bear the UL label. All incandescent lamps shall be rated for 130 volts unless otherwise indicated.

16-1.4.17.2 Fluorescent fixtures. Unless otherwise indicated, lenses for fluorescent fixtures shall be the prismatic type, made of virgin acrylic. Fluorescent lamps shall be rapid start, cool white unless otherwise indicated. Ballasts for fluorescent fixtures shall be class P, rapid start, high power factor type, without automatic thermal resetting capability, conforming to Federal Specification W-B-30. All ballasts shall be provided with factory installed choke type radio frequency interference suppressors. All ballasts shall bear the CBM/ETL label. Lamp holders shall have silver plated contacts, and shall conform to UL 542.

16-1.4.17.2.1 Recessed fluorescent fixtures. Not acceptable for usage

16-1.4.17.2.2 Suspended fluorescent fixtures. Not acceptable for usage.

16-1.4.17.3 Suspended incandescent fixtures. Not acceptable for usage.

16-1.4.17.4 Emergency lights. Emergency lights shall conform to Federal Specification W-L-305, Type I, Class I, Style D or E, and with the number of heads as indicated on contract drawings. Emergency light sets shall be connected to the wiring system by a cord no greater than 3 feet in length and a single receptacle.

16-1.4.17.5 High intensity discharge (HID) lamps. HID lamps including mercury vapor, metal halide, and high or low pressure sodium shall be as indicated on the drawings. High power factor, constant wattage ballasts shall be furnished with HID lamps. Mercury vapor lamps shall be the color improved type.

16-1.4.18 Painting and finishing. Field applied paint on exposed surfaces shall be provided under the painting section of these specifications. Where factory finishes are not adequate to protect metal surfaces from corrosion, the Contractor shall paint exposed surfaces prior to or after installation. Where factory finishes are provided on equipment and no additional field painting is specified, all marred or damaged surfaces, except exposed metal for grounding purposes, shall be refinished to leave a smooth, uniform finish at the time of final inspection.

16-1.4.19 Repair of existing work. Electrical work shall be carefully laid out in advance. Where cutting, channeling, chasing, or drilling of floors, wall partitions, ceilings, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, it shall be carefully done. The Contractor shall immediately repair, with equal material by skilled workmen, any damage made by his workmen, equipment or work. Prior approval of the RE must be obtained for the materials, workmen, time of the day and night, method of repairs, and for temporary and permanent repairs

the Contractor proposes to make. Any repair work, upon completion, shall be inspected and approved by RE with the concurrence of the affected utility company and/or airport sponsor.

16-1.5 Quality assurance provisions.

16-1.5.1 Materials and equipment. Within 15 days after notice to proceed, and before installing any materials or equipment, the Contractor shall submit three copies of the complete materials and equipment to the RE for approval.

16-1.5.1.1 Information required. This list shall include manufacturer's style or catalog numbers and manufacturer's catalog cuts. Partial lists submitted from time to time shall not be considered as fulfilling this requirement. Approval of materials will be based on manufacturer's published data. Approval of materials and equipment will be tentative, subject to submission of complete shop drawings, when required.

Submittals shall comply with specifications and contract documents, subject to RE's approval.

16-1.5.1.2 Statement. A manufacturer's statement indicating complete compliance with the applicable Federal Specification, Military Specification, or standard of the American Society for Testing and Materials, National Electrical Manufacturers Association, or other commercial standard, is acceptable as indicating compliance with specifications and contract documents.

16-1.5.2 Shop drawings. By the direction of the RPR, the Contractor shall submit shop drawings for materials and equipment not completely identified by information submitted in the materials and equipment lists. This information shall include, but not limited to panel boards, lighting fixtures, cable trays, switchgear, transformers, busways, cabinets, and lightning protection systems. Three (3) copies of all shop drawings shall be submitted for approval at least 30 days prior to proposed installation.

16-1.5.2.1 Coordination. Drawings and submitted data shall be checked and coordinated with the work of other construction trades involved, before they are submitted for approval, and shall bear the Contractor's stamp of approval as evidence of such checking and coordination.

16-1.5.2.2 Required data. Drawings and submitted data shall be complete, assembled in sets and shall bear:

A. Date

B. Drawing revision number

C. Name of project or facility

D. Name of Contractor and lower tier Contractors

E. Clear identity of contents and location of work.

The Contractor shall submit all drawings and data sufficiently in advance of contract requirements to allow ample time for checking, resubmitting, and rechecking. The Contractor shall allow 14 calendar days for review of any one submission.

16-1.5.2.3 Approval. The approval of drawings and submitted data will be general, but except as otherwise provided herein or in the contract, approval shall not be construed: (1) as permitting any departure from the contract requirements; (2) as relieving the Contractor of the responsibility for any errors, including details, dimensions, materials, etc.; or (3) as approving departures from full size details furnished by the RPR.

16-1.5.2.4 Variations. If drawings show variations from the contract requirements because of standard shop practice or for other reasons, the Contractor shall describe such variations in his letter of transmittal to the RPR. If acceptable, the RPR may approve any or all such variations, subject to a proper adjustment in the contract.

If the Contractor fails to describe such variations, he shall not be relieved of the responsibility for executing the work in accordance with the contract, even though such drawings have been approved.

16-1.5.2.5 Submission. The Contractor shall submit and obtain approval of shop drawings from the RPR before ordering materials or proceeding with any work associated with the shop drawings.

16-1.5.3 Tests.

16-1.5.3.1 General. The Contractor shall furnish all test instruments, materials and labor necessary to perform the following tests. All tests shall be performed in the presence of the RE. All instruments shall have been calibrated within a period of two (2) years preceding testing. Calibrations shall be traceable to applicable industry recognized standards. All testing shall be performed by qualified testers, regularly engaged in this type of work.

16-1.5.3.2 Cables. All cables shall be tested in accordance with FAA Order 6950.22 prior to installation, after each splice, and again upon completion of the installation. Testing shall be done on the installed cables before connection is made to any existing equipment.

16-1.5.3.3 Load balancing. After the electrical installation has been completed, the Contractor shall take current readings with a clamp-on ammeter on each phase of each panel board feeder, and on the main service conductors. The Contractor shall redistribute single phase loads where greater than a 20% difference between readings in any two phases. Where load balancing requires moving a conductor between phases, the original conductor shall be re-identified by tape in accordance with paragraph 16-1.4.6.4.2.2, color coding. If the Contractor finds any phase loaded above 80% of the rating of its overcurrent protective device, he shall notify the RPR.

16-1.5.3.4 Insulation resistance tests. Feeders and branch circuits shall have their insulation tested after installation, but before connection to fixtures or appliances. Motors shall be tested for grounds or short circuits after installation but before start-up. All conductors shall test free from short circuits and grounds, and a minimum phase-to-phase and phase-to-ground insulation resistance of 30 megohms measured with a 500 - 1000 DC volt insulation resistance tester. The Contractor shall submit a letter type test report to the RPR prior to final inspection of the Contractor's work. The report shall list the tests performed and results obtained.

16-1.5.3.5 Neutral isolation test. For all new installation, the neutral in the safety disconnect switch shall be tested for isolation from ground with a low impedence ohmmeter capable of reading greater than 20,000 ohms.

This procedure can also be used to determine if there are any other neutral-to-ground connections on load side of the service disconnecting means testing for a resistance value higher than 20,000 ohms between the disconnected neutral and the ground.

16-1.5.3.6 Earth resistance test. To demonstrate compliance with paragraph 4.4.4, the Contractor shall measure the resistance to the grounding electrode system using the Wenner Vertical Profiling method (ASTM G57). With this array, potential electrodes are centered on a traverse line between the current electrodes, and an equal spacing between electrodes is maintained. Ground resistance measurements shall be made before the electrical distribution system is energized. Tests shall not be conducted within 48 hours of a rainfall, or in frozen soil. The Contractor shall immediately notify the RPR if the specified resistance is not obtained. Upon project completion, the Contractor shall submit a written test report, defining his test procedure and results obtained, to the RPR.

16-1.5.3.7 Operating test. After the interior wiring system installation is completed, and at such time as the RPR may direct, the Contractor shall conduct an operating test for approval. The equipment shall be demonstrated to operate in accordance with the requirements of this specification. The test shall be performed in the presence of the RPR.

16-2 Method of measurement.

16-2.1 Basis of measurement. The installation of constant current regulators (CCR) will be measured on a per each basis and shall consist of a complete workable unit.

The Earth Electrode System (EES) shall be measured on a per each basis and shall consist of a complete workable unit ready for operation and accepted as satisfactory by the RPR.

The utility meter rack shall be measured on a per each basis and accepted as satisfactory by the RPR.

The lightning protection system shall be measured on a per each basis and shall consist of complete workable unit ready for operation and accepted as satisfactory by the RPR.

16-3 Basis of payment.

16-3.1 CCR installation. The payment for each CCR installation shall be compensation for installing the furnished CCR in the designated location, completing all power and control terminations, providing and installing misc. conduit, and installing the provided main lighting controller. Said payment shall be compensation for all labor, equipment and materials required to complete a working unit.

16-3.2 Earth electrode system. The payment for the EES shall be on a lump sum basis for providing and installing all the components necessary for a complete and working system including the ground rods, conductors, trenching and exothermic welds. Said payment shall be compensation for providing all labor, equipment and materials required to construct a complete and working system.

16-3.3 Installation of lightning protection system. The payment for the installation of lightning protection system shall be on a lump sum basis for installing the government provided kit consisting of air terminals, down conductors and making exothermic terminations to the grounding system. Said payment shall be compensation for all labor, equipment and materials required to complete a working unit.

16-3.4 Utility meter service, Shelter 1. The payment for the utility meter service per shelter shall be on a lump sum basis for providing and installing all the components required to construct a complete unit of work consisting of the rack as detailed in the plans, including the meter base, conduit, handholes/manholes, backfill, grounding and conductors from the point of connection to the local utility to the main disconnect inside the shelter. Said payment shall be compensation for all labor, equipment and materials required to complete a working unit.

16-3.5 Utility coordination, Shelter 1. The payment for utility coordination shall be compensation on an allowance basis for the following:

1. Pre-construction meeting with electric utility (MLGW) to confirm the service installation plan, coordinate inspection requirements, and discuss other MLGW requirements as needed.
2. Assisting MLGW with inspection of service entrance feeders and service entrance disconnect rack, including implementation of any corrective actions and subsequent inspections required by MLGW.
3. Assisting MLGW with installation of the service entrance feeder cables, meter socket, and associated instrument transformers in service entrance disconnect rack.
4. Provide all required scheduling, coordinate site access for MLGW, and provide a minimum of one electrician to escort and actively support MLGW each time they are on site.

Said payment for utility coordination shall be compensation for all labor, equipment and materials required to complete the electrical service installation and energize electrical service to the site.

Payment will be made under:

Item 16-3.1	CCR Installation - per each
Item 16-3.2	Earth Electrode System - per lump sum
Item 16-3.3	Installation of Lightning Protection System - per lump sum
Item 16-3.4	Utility Meter Service, Shelter 1 - per lump sum
Item 16-3.5	Utility Coordination, Shelter 1 - allowance

END OF ITEM 16