SPECIFICATION L-100. AIRPORT LIGHTING GENERAL PROVISIONS

DESCRIPTION

100–1.1 These Specifications cover requirements for all Airport lighting installations in Part XI.

NOTE TO SPECIFIER:

The following "General Requirements" section was developed to provide standard electrical construction instructions for all electrical Contract Documents, including WisDOT Standard Specifications, details and special engineered drawings. This information is communicated to the Contractor in 100–2.1.

The following Wiring "Methods and Materials" were developed to provide electrical products to build WisDOT WBOA standard specifications L–101 through L–125 and WisDOT standard details only. This section is not intended for engineered drawings, unless the special provisions explicitly mentions that this section is included. This information is communicated to the Contractor in paragraphs 100–3.1.

All Standard Specifications in L–100 were developed to provide information consistent with typical electrical trade construction. This information is in greater volume than before, so it is now located in its own section, rather than repeated in each specification section.

All standard L–100 specifications now incorporate the material design requirements typically found in the AC 150/5340 series, which were typically communicated to the Contractor through Drawings and Special Provisions.

All Standard L–100 Specifications now incorporate the material design requirements typically found in the FAA Regional Supplement and other FAA directives, which were typically communicated to the Contractor through Drawings and Special Provisions.

The Standard L–100 Specifications were not developed to replace or conflict with pre–manufactured products built under the AC 150/5345 series, or products listed under the jurisdiction of testing laboratories mentioned in ILHR 16.11.

Standard L–100 specifications were not developed to duplicate or replace wiring methods and materials mentioned in Chapter ILHR 16. L–100 either establishes a grade of construction that exceeds the requirements of ILHR 16, or defines and selects methods and materials where ILHR 16 offers a choice.

A hierarchical document precedence for WisDOT airport electrical construction should proceed as follows:

1) The Construction Contract Proposal has first precedence. By reference, it establishes that the WisDOT Standard Specifications for Airport Construction are included.

2) By association, Part I Section 5–03 establishes that the Special Provisions have precedence over all other Drawings and Specifications. If the Special Provisions do not alter the WisDOT Electrical Standard Specifications, then these Standard Specifications have the next precedence.

3) By reference, Part XI establishes the standard electrical specifications that are to be used. The standard electrical specifications for FAA products are governed by the AC 150/5345 series, and take precedence over all other product specifications. FAA electrical products are only accepted through ETL testing and FAA certification, and cannot be modified. The standard electrical equipment specifications for all other products required to install FAA products, or to build airside facilities for FAA installations, in accordance with WisDOT Standard Pay Items, are governed by Specification L–100–3.1. Specification L–100–3.1 has precedence over all other specifications for the Standard Pay Items and details, and cannot be modified unless approved by the Department.

L–100–3.1 specification has a reference section for each product that lists testing laboratories, agencies and societies that govern the product specifications. These laboratories, agencies and societies have precedence over the manufacture of these products, and these specifications cannot be modified. L–100–2.2 also references ILHR 16. This Wisconsin State.

GENERAL REQUIREMENTS

100–2.1 The following General Requirements specifications govern all Contract Documents. Perform all Work in strict accordance with these Specifications. Conform with the latest edition of the applicable FAA advisory circulars and revisions for installation details and material and equipment specifications. Provide airport lighting equipment from the FAA approved equipment list in the latest edition of AC 150/5345–53 Appendix 3. The list is also available through the FAA web page, http://www.faa.gov/.

Furnish all other basic wiring materials and products as listed by Underwriters Laboratories and as suitable for the purpose specified.

All installation shall be in accordance with National Electrical Contractors Association (NECA) "Standard of Installations".

Contractor's workers shall be trained and experienced in installing, testing and repairing Airport lighting systems. Keep a copy of FAA Advisory Circular (AC) 150/5340–26, and be familiar with its contents. Maintain a copy of the AC on site and follow all pertinent aspects as it relates to the Work. The AC is available through the FAA web page, http://www.faa.gov/.

100–2.2 CODES AND REGULATORY REQUIREMENTS. Comply with all ordinances, laws, regulations and codes applicable, in particular, the Wisconsin Administrative Code Chapter ILHR 16 Volumes 1 and 2, and the Life Safety Code. This compliance does not relieve the Contractor from furnishing and installing Work shown or specified which exceeds the requirements of such ordinances, laws, regulations and codes.

NFPA 70 is included by reference in ILHR 16.12. Coincidentally, Chapter ILHR 16 is also inclusive even where NFPA 70 is the only reference mentioned.

Obtain inspections, approvals, and plan and specification reviews required by State Statutes, codes, rules, laws or ordinances. Pay all costs and fees for inspections, approvals, and plan and specification reviews.

Have, as a minimum, one electrician certified by the State of Wisconsin on the project. If there are local regulations relating to licensing or certification, the more stringent requirements will governed.

NOTE TO SPECIFIER:
Whereas the Contractor is responsible for compliance with all State Statutes, the requirement for certification is included. Certification also places the responsibility for Wisconsin Code compliance onto the installer. The Engineers are encouraged to include this statement in these specifications; however, if specifiers determine a certified electrician is not advantageous, they may delete this requirement by Special Provision, upon approval by the WBOA.

100–2.3 ELECTRICAL UTILITY SERVICE POINT. Electrical utility power services required by the Contract Documents shall include all Work from the utility point of service to the service main disconnect switch.

"Construction limits" designations that are indicated on Contract Documents shall not apply to Electric Utility Service work necessary to serve the project and occurring outside of the "construction limits" designations. Pay for the cost for all Work by the Utility company.

Definitions:

Throughout the Specification, two terms are used to describe electrical systems that provide power for lighting and control equipment. The terms used are "Power Source" and "Utility Service". "Power Source" refers to products and materials necessary to connect, distribute, protect, and provide an electrical source for the circuits that feed lighting and control equipment. Under most circumstances, this includes circuit breakers, disconnect switches, boxes, building feeder circuits, branch circuits, raceways, splices, connections, and attachments. Depending on the circumstances, it may include outdoor direct burial feeders, control, and branch circuits. Although each project may vary, typically a Power Source is derived from an existing "Utility Service" and Distribution System, and all work to install a "Power Source" is incidental to some other work.

"Electric Utility Service" refers to products and materials necessary to bring a Public Utility electrical source to the point where it connects to a "Power Source". Under most circumstances, this includes permits, fees, utility poles, transmission circuits, service laterals, utility transformers, or provisions for transformers, service metering equipment, main service disconnect switch, and any costs incurred by the Public Utility on and off the project site, inside and outside the construction limits, in order to bring electrical power to a service point. Although each project may vary, typically a "Utility Service" is a new electrical power system and is paid for independently of all other work.

100–2.4 EXCAVATION. Provide excavation for underground Work in accordance with the construction methods and requirements of Part II Earthwork. Compact backfill for trenches to densities required for adjacent embankment and cut areas.

100–2.5 CONCRETE. Concrete shall be in accordance with Specification P–610.

100–2.6 CUTTING AND PATCHING. Perform all cutting and patching necessary in order to do the Work. Obtain special permission from the Engineer before cutting structural members of finished material. Perform all patching to return the part affected to the condition equal to or exceeding the undisturbed Work.

100–2.7 CLOSING OF OPENINGS.
Firestopping. Close and seal all unused slots, sleeves and other penetrations in fire rated floors, walls or other general construction with an approved firestopping material.

Firestopping material shall be UL listed and tested silicone elastomer specifically formulated for use in horizontal and vertical applications. Material shall possess expansion characteristics and upon exposure to heat above 250°F shall expand to not less than five times its original volume to form a fireproof envelope. Firestopping material shall be UL listed for 3–hour protection, applied in accordance with the manufacturer's recommendation.

Close openings in floor slabs with 16 gauge galvanized steel sheet, securely attached with power–driven studs into the building structure. Firestop with a layer of silicone elastomer not less than 1 inch thick which completely fills the opening. Locate the sheet steel so that the top surface of the silicone elastomer is approximately 1 inch below the finished floor slab.

Close openings in walls with 16 gauge galvanized steel sheet securely attached at the midpoint of the wall thickness and firestopped on both sides of the steel sheet with not less than 1/2–inch thick layer of non–sagging silicone elastomer to fully cover the opening.

Single or multiple pipes passing through walls and floors shall have the annulus space between pipes or between pipes and structure filled with silicone elastomer to provide a 3–hour rated firestop for floors and walls.

Perform patching Work with experienced workers, skilled for the particular type of Work involved. Repair all cut surfaces and match adjacent surfaces. Drill all holes in masonry with rotary drills.

100–2.8 PAINTING AND FINISHING DAMAGE AND TOUCH–UP. Repair all marred or damaged painted finishes with materials and procedures to match original finishes.

100–2.9 ACCEPTANCE OF MATERIALS AND EQUIPMENT. Acceptance of equipment, where applicable, will be based on Section 100–2.10. Be prepared to submit samples of equipment or material for review when requested by the Engineer.

Contractor installed equipment (including FAA approved) shall not generate any electromagnetic interference in the existing and/or new communications, weather, air navigation, and air traffic control equipment. Replace equipment generating interference at no additional cost, with equipment not generating interference and meeting the applicable specifications.

Ascertain that all furnished lighting system components (including FAA approved equipment) are compatible in all respects with each other, and the remainder of new or existing systems. Replace contractor furnished non–compatible components at no additional cost to the Department. Manufactured items furnished shall be the current, cataloged product of the manufacturer. Replacement parts shall be available. There shall be a permanent service organization maintained or trained by the manufacturer to provide repair and replacement services.

Follow the manufacture's installation instructions. Accept full responsibility for their equipment and product selection, cost for materials, effort of installation and the compatibility with airport lighting equipment specified for the project.

Where installation procedures are required to be in accordance with manufacturers' recommendations, have printed copies of the recommendations prior to installation. Do not proceed with installation of the item until recommendations are received. Failure to use recommendations shall be cause for rejection of the equipment or material.

Replace damaged or broken materials or products. Field repair may be authorized in writing by the Engineer instead of replacement on items with long delivery lead times. Repair authorization shall be in written form.

100–2.10 SHOP DRAWINGS. Submit six sets of shop drawings for all electrical equipment. Reference the Specification's article to which each shop drawing is applicable. Include complete catalog information such as product illustrations, ratings, and dimensions as applicable. Submit shop drawings in complete groups of materials (i.e. cables, all lighting fixtures, etc.), and sign each item of material submitted as verification that submittal has been reviewed in detail and is in fact, the Contractor's choice of materials. Bind catalog cuts, plate numbers, descriptive bulletins and drawings (11" x 17" or smaller) in sets with covers showing titles. Verify dimensions of equipment and be satisfied as to code compliance for fit prior to submitting shop drawings for approval. When vendor sheets include more than one product code or catalog data, highlight the data pertinent to the specified material.

Include with each submitted shop drawing the following paragraph:

"It is hereby certified that the (equipment) (material) shown and marked in this submittal is that proposed to be incorporated into the project, it is in compliance with the Contract Documents and Specifications, and can be installed in the allocated spaces. Failure to add the preceding statement or any departure from the enclosed procedure will result in delay of review of submittal. Electrical equipment subject to shop drawing review will be inspected by the Engineer before installation commences. Equipment that cannot be inspected in place, shall be exposed for inspection upon request of the Engineer. Replace non–conforming equipment at the Contractor's expense.

NOTE TO SPECIFIER:
The engineer should note in the special provisions which materials required shop drawing review to meet the intent of Section 100–2.10.
The quantity of six shop drawings is designated for distribution as follows:

1 – office copy for the design Engineer
1 – field copy for the resident Engineer
1 – office copy for the Contractor
1 – field copy for the Contractor
1 – office copy for the Owner
1 – copy for return to the Vendor
The Engineers should adjust the number of copies at their discretion.

100–2.11 OPERATING AND MAINTENANCE MANUAL. Prepare Operation and Maintenance (O&M) Manuals for all electrical equipment furnished under the Contract. Provide three copies to the Engineer.

The information included must be the exact equipment installed, not the complete "line" of the manufacturer. Where sheets show the equipment other than the equipment actually installed, neatly and clearly identify the installed equipment on the sheets. Give full ordering information assigned by the original parts manufacturer for listed parts. Relabeled and/or renumbered parts information as reassigned by equipment supplier is not acceptable.

Manuals shall contain shop drawings, wiring diagrams, operating and maintenance instructions, replacement parts, lists, and equipment nameplate data for all control equipment and systems installed under the description information designed to acquaint Sponsor's maintenance personnel with equipment operation in each mode of operation. In addition, each manual shall contain a set of the project record drawings reduced to 11" x 17".

Wiring diagrams for each piece of control equipment and system shall be complete drawings for the specific product installed under the contract. "Typical" line diagrams are not acceptable.

Group the information contained in the manuals in an orderly arrangement by specification Table of Contents. Include a typewritten index and divider sheets between categories with identifying tabs in the manuals. Bound the completed manuals with hard board 3–ring binders. Imprint the name of the job, Sponsor, Contractor, and year of completion on the covers. Imprint the name of the job, Sponsor, Contractor, and year of completion on the back edge.

Submit a preliminary copy to the Engineer prior to completion of the project for review. Deliver the three corrected copies to the Sponsor before final payment is approved.

NOTE TO SPECIFIER:
The three O & M manuals required are intended for distribution as follows:
1. Sponsor – 1 copy;
2. Design Engineer – 1 copy;
3. Airport Maintenance – 1 copy.
If additional copies are required, a Special Provision should be added.

100–2.12 TESTS. Conduct the acceptance test for equipment in the presence of the Engineer, which includes demonstrations, instructions, and tests as outlined in the respective Shop Drawings, equipment and system specifications, and as required by the Special Provisions.

NOTE TO SPECIFIER:
The Engineer should add Special Provisions and possible Pay Items to define tests, as deemed necessary to exceed testing outlined in the requested equipment and system specifications.

a. Make available at the site the following test equipment:

(1) Voltmeter/OHM with proper scales.

(2) Clamp–on ammeter with proper scales.

(3) Meggar to measure conductor insulation resistance with 100V, 500V and 1000VDC outputs.

(4) Grounding system resistance tester.

(5) High voltage probe for measuring up to 5000 VAC.

Test equipment shall remain the property of the Contractor.

b. Have available a licensed electrician with necessary tools and materials to perform the following:

(1) To open and close equipment enclosures, covers to junction boxes, terminal panels and wireways when directed.

(2) To open and reconnect splices other than the cast type when directed.

(3) To make tests and demonstrate system performance.

100–2.13 FACILITY STARTING AND COMMISSIONING. Do not energize illuminated navigational aid equipment included in the Contract Documents for Sponsor use until the Engineer has inspected and the Department has given written authorization for use to the Contractor. Prior to the written authorization, the Contractor may energize the equipment for short periods for testing purpose only and as approved by the Engineer. Do not operate unattended equipment, illuminated navigational or otherwise, until it has been fully prepared, connected, tested, and made ready for normal operation. Correct damage to equipment occasioned by improper or ill–timed operation or testing at the Contractor's expense.

Provide a written statement saying the date and time when the navigational aid equipment will be available for testing and operation. Equipment warranties will be in effect on the date of the written authorization by the Department.

All equipment requiring operation during construction shall require operating instructions for systems and equipment indicated in the Contract Documents. Include in the operating instructions wiring diagrams, control diagrams, and operating and control sequence for each principal system and equipment. Post instructions where directed or attach the operating instructions adjacent to each principal system and equipment including start–up, operating, shutdown, safety precautions and procedures in the event of equipment failure. Provide weather–resistant materials or weatherproof enclosures where appropriate for operating instructions exposed to the weather. Operating instructions shall not fade when exposed to sunlight and shall be secured to prevent easy removal. Prior to project final acceptance and receipt of the O&M Manuals, furnish full instructions for the care, adjustments, and operation and maintenance of all electrical equipment that functions by automation or manual control to the Sponsor's designated representative.

NOTE TO SPECIFIER:
The engineer will need to provide a special provision for the extent of instruction should they deem this effort necessary.

100–2.14 CONTRACT DRAWING. Before roughing–in facilities or installation of equipment, consult all Drawings for obstructions that affect the installation. Verify that field measurements and circuiting arrangements are as shown on Drawings, and that abandoned wiring and equipment serve only abandoned facilities.

The location of the circuits and conductors on the Drawings are diagrammatic, and subject to dimension provided in the details, and as determined by the actual field conditions.

Space requirements and dimensions are nominal and based on typical manufacturer's data, with proper electrical clearances. The Contractor is totally responsible for selecting products that fit the available space, or expanding the given spaces to comply with their bid equipment, plus the necessary NEC code space. The Contractor will not be allowed extra compensation for their bid equipment that does not fit the available space.

100–2.15 CONTRACT DRAWING SYMBOLS AND ABBREVIATIONS. Refer to Symbols and Abbreviations illustrated on Drawings. Other symbols are in common usage, but if uncertainty exists regarding Plan symbols or abbreviation, bring it to the attention of the Engineer for clarification.

NOTE TO SPECIFIER:
A list of Symbols and Abbreviations should be added to the Plans.

100–2.16 CONTRACT DRAWING RECORDS. The Engineer will furnish a newly printed set of Contract Drawings for the Contractor to mark where construction differed from the original Drawings. Keep the set on site at all times and complete this Work and give the Drawings to the Engineer before final payment is approved.

100–2.17 DEMOLITION. Review all the demolition required by the Contract Documents to be removed, relocated, terminated, or extended to accommodate the new construction. As a minimum, the following is required:

a. Remove abandoned wiring to the source of supply.

b. Remove exposed abandoned conduit, including abandoned conduit behind accessible finishes. Cut conduit so that it is recessed with walls and floors, and patch surfaces.

c. Disconnect abandoned electrical outlets and remove devices. Remove abandoned outlets if conduit servicing them is abandoned and removed. Provide blank covers for abandoned outlets that cannot be removed.

d. Disconnect and remove electrical devices and equipment servicing abandoned outlets that have been removed.

e. Repair adjacent construction and finishes damaged during demolition work.

f. Maintain access to existing electrical installations which remain active. Modify installation or provide access to splices as appropriate.

g. Extend existing installations using materials and methods compatible with existing electrical installations, or as specified.

Demolition drawings are schematic and are based on existing record documents. Report discrepancies to the Engineer before disturbing existing installations. Beginning of demolition signifies that the Contractor has investigated existing conditions and accepts the demolition requirement under these specifications.

NOTE TO SPECIFIER:
If demolition is extensive, a Drawing, Special Provision, and special Pay Item may be necessary to separate a major cost for demolition.

WIRING METHODS AND MATERIALS

100–3.1 GENERAL. The following Wiring Methods and Materials Specifications govern airside electrical installations that are not otherwise covered by Advisory Circulars or other Parts of the Standard Specifications, and are intended to supplement the Standard Electrical Specifications L–101 through L–125 only.

These Specifications are not intended to govern FAA approved manufactured assemblies tested under ETL, airport landside installations, or Special Provisions, unless they are explicitly mentioned as being included by the Special Provisions.

Definitions:

Airside equipment refers to equipment installed as part of the airfield electrical systems governed or covered by FAA regulations, with restricted access to unauthorized personnel.

Landside equipment is electrical equipment installed as part of public and passenger handling areas, unrestricted.

NOTE TO SPECIFIER:
If engineers intend to use Sections 100–3.2 through 100–3.13 for engineered airside installations, special pay items, they must explicitly mention the inclusion in their special provisions.

100–3.2 RACEWAYS. Provide raceways at locations indicated on the Drawings and in accordance with the following specifications. Refer to Specification L-110 for underground electrical duct bank installations.

a. Section Includes.

(1) Rigid Steel and Intermediate Conduit.

(2) Rigid Nonmetallic Conduit.

(3) Electrical Metallic Tubing.

(4) Flexible Metal Conduit.

(5) Flexible Polyethylene Duct, Coupling and Connectors.

(6) Liquid–tight Flexible Metal Conduit.

(7) Wireway, Auxiliary Gutters.

(8) Raceway Fittings, Couplings and Connectors.

(9) Bituminous Fiber Duct.

b. References.

(1) American National Standards Institute (ANSI). Comply with requirements of the following.

ANSI	C80.2	Rigid and Steel Conduit.
ANSI	C80.3	Electrical Metallic Tubing (EMT), Zinc Coated.
ANSI	870	Wireways, Auxiliary Gutters and Associated Fittings.

(2) National Electrical Manufacturers Association (NEMA). Comply with the requirements of the following.

NEMA	TC2	Electrical Plastic Tubing (EPT) and Conduit (EPC–40 and EPC–80).
NEMA	TC3	Fittings for PVC Conduit.
NEMA	TC7	Flexible Polyethylene Duct.

(3) National Fire Protection Association (NFPA). Comply with requirements of the following.

NFPA	70	National Electric Code.

(4) Underwriters Laboratories, Inc. (UL). Comply with the requirements of the following.

UL	1	Flexible Metal Conduit.
UL	360	Liquid–Tight Flexible.
UL	514B	Fittings for Conduit and Outlet Boxes.
UL	886	Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.
UL	1242	Intermediate Metal Conduit. Steel Conduit.
UL	543	Bituminous Fiber Duct.

c. Products.

(1) Rigid Steel Conduit and Intermediate Metal Conduit (IMC).

(a) Use for stub–ups from direct burial and wherever susceptible to severe physical damage.

(b) Use in hazardous (classified) location and Class I, Division 2.

(c) Use for burial in concrete slabs or concrete encasement.

(d) Use for direct contact with earth.

(2) Rigid Nonmetallic Conduit.

(a) Schedule 40–Use for direct burial under driveways and parking lots only. Use under runways, taxiways, and aprons only when encased in concrete.

(b) Schedule 80 – Use for direct burial and stub–ups from direct burial for a distance of two feet maximum. Use as an alternate to Rigid Steel and IMC Conduit, for stub up work only.

(3) Electrical Metallic Tubing (EMT).

(a) Use for branch circuits in dry locations.

(b) Do not bury in ground or in slabs.

(c) Do not use in concrete.

(d) Do not use for circuits operating over 600–volts.

(4) Flexible Metal Conduit.

(a) Use in dry locations.

(b) Do not use in corrosive atmosphere or concealed work exterior locations.

(c) Use wherever equipment must be isolated for vibration or shifted to its final position.

(5) Flexible Polyethylene Duct, Couplings, and Connectors.

(a) Use for conductors and cables below grade installed in trench or by plowing methods as an alternate to underground cable installed in trench with sand base and backfill.

(b) Do not use above grade.

(6) Liquid–Tight Flexible Metal Conduit.

(a) Use for exterior and damp locations.

(b) Sizes 1–1/4–inch and smaller, provide with a continuous copper bonding conductor wound spirally between convolutions.

(c) Sizes 1–1/2–inch and larger, provide with an internal grounding conductor and grounding bushings.

(7) Wireways, Auxiliary Gutters.

(a) May be used to facilitate installation and future changes in wiring between panelboards, safety switches in close proximity to each other on same or adjacent walls or in same electrical equipment room or area.

(b) Provide NEMA 4 stainless enclosure where outdoors or subject to moisture and similar elements.

(c) Do not use for constant voltage circuits operating over 100V, unless an equipment grounding conductor is used and bonded to each wireway joint, and bonded to the grounding electrode conductor.

(8) Raceway Fittings, Couplings and Connectors.

(a) Use fittings listed and approved for specific conduit or raceway system used. For threaded rigid steel conduit do not use threadless or compression type fittings. For EMT, provide steel or malleable iron "concrete–tight" or "rain–tight" couplings and connectors, compression type or stainless steel multiple locking type. Do not use indentation or set screw type fittings.

(b) Bushing and connectors shall be insulated type which maintain continuity of conduit grounding system. Mold or lock insulating material into the metallic body of the fitting. Bushing made entirely of nonmetallic material will not be allowed.

(c) Connectors and couplings body shall have wall thickness at least equal to wall thickness of conduit used.

(d) Provide flexible metal conduit fittings made of steel of malleable iron and one of the following types:

Screw type having an angular wedge fitting between the convolutions of the conduit.

Squeeze or clamp type having a bearing surface contoured to wrap around the conduit and clamped by one or more screws.

Steel, multiple point type, for threading into internal wall of the conduit convolutions.

(e) Liquid–tight flexible metal conduit shall incorporate a steel, nylon or equal plastic compression ring and a gland for tightening. The fitting shall be steel, or malleable iron with insulated throat, with male thread and locknut or male bushing with or without "O" ring seal.

(f) Provide expansion fittings for all rigidly fastened conduits spanning a building expansion joint and if not otherwise mentioned, for all runs exceeding 150 feet in length. Fittings shall be hot–dipped galvanized malleable iron with a packing ring to prevent entrance of water, a pressure ring, a grounding ring and a separate external copper bonding jumper.

(g) Do not use material such as "pot metal" for any type of fitting.

d. Installation.

Complete installation of electrical raceways before starting installation of cables/wires within raceways.

Prevent foreign matter from entering raceways; use temporary closure protection.

During construction, protect stub–ups from damage. Arrange so curved portion of bends is not visible above the finished slab or grade.

Make bends and offsets so the inside diameter is not effectively reduced.

Unless otherwise indicated keep the legs of a bend in the same plane and the straight legs of offset parallel.

Use raceway fittings that are of types compatible with the associated raceway and suitable for the use and location.

Run concealed raceways with a minimum of bends. All bends shall have the longest possible radii.

Install exposed raceways parallel and perpendicular to nearby surfaces or exposed structural members, and follow the surface contours.

Run exposed, parallel or banked raceways together.

Make bends in parallel or banked runs from the same center line so that the bends are parallel. Factory elbows may be used in banked runs where they can be installed parallel.

Where the installation is such that joints cannot be made tight, use bonding jumpers to provide electrical continuity of the raceway system.

Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the protection shoulder.

Where chase nipples are used, align the raceway and coupling square to the box and tighten the chase nipple so no threads are exposed. Running threads are not allowed.

Install pull wires in empty raceway. Use No. 14 AWG zinc–coated steel or plastic having not less than 200 pounds tensile strength unless indicated otherwise in the Contract Documents. Leave not less than 12 inches of slack at each end of the pull wire.

In slabs and walls, locate raceways in middle third and leave at least 2 inches concrete cover. Lateral spacing of raceways shall be not less than three diameters of the raceway.

Tie raceway to reinforcing rods or support to prevent sagging or disturbing when concrete is placed.

At expansion joints, provide expansion fittings and cross at right angles to joint.

Provide conduits stubbed up through or from concrete floor for connection to freestanding equipment with an adjustable top or coupling threaded inside.

Provide flexible conduits only for connections to electrical equipment when it is subject to movement, vibration, misalignment, or where noise transmission is to be eliminated or reduced. Install all bonding and grounding conductors for liquid–tight, flexible metallic conduit runs within the conduit. Allow all PVC conduits directly buried to acclimate to the installed temperature before installation commences (one hour minimum). Flexible conduit shall be of the liquid–tight type when installed under any of the following conditions:

(1) Exterior locations (ultra violet light rated)

(2) Moisture or humidity laden atmospheres where it is possible for condensation to accumulate. Corrosive atmospheres.

(3) Wherever there is a possibility of seepage or dripping of oil, grease, or water.

(4) Raceway Sealing Fittings shall be zinc coated, cast or malleable iron type. Use continuous drain type fittings that are used to prevent passage of water vapor..

(a) Upon completion of installation of raceways, inspect interiors of raceways at all outlet, junction and pull boxes, and remove burrs and obstructions.

(b) Run a swab or mandrel to remove dirt and blockages. Replace new raceways that are deformed and prevent the passage of a mandrel. Replace used raceways that are deformed and prevent the passage of a mandrel at the Engineer's discretion with payment in accordance with Extra Work Section 40–04.

(c) Remove dirt and construction debris from outlet, junction and pull boxes.

100–3.3 FEEDER AND BRANCH CIRCUIT WIRE AND CABLE.

Provide feeder and branch circuit wire and cable at locations indicated on the Drawings and in accordance with the following Specifications. Refer to Specification L-108 for underground cable installations.

a. Section Includes.

(1) Copper conductors.

(2) Tap type connectors.

(3) Split–bolt connectors.

(4) Wire nut connectors.

b. References.

(1) American Society for Testing and Materials (ASTM). Comply with requirements of the following:

ASTM	B 1	Standard Specification for Hard Drawn Copper Wire
ASTM	B 2	Standard Specification for Medium–Hard–Drawn Copper Wire
ASTM	B 3	Standard Specification for Soft or Annealed Copper Wire
ASTM	B 8	Standard Specification for Concentric–Lay–Stranded Copper Conductors, Hard, medium–Hard, or Soft
ASTM	D 753	Standard Specification for General Purpose Polychloroprene Jacket for Wire and Cable.

(2) Institute of Electrical and Electronics Engineers (IEEE). Comply with the following standards which apply to wiring systems:

IEEE	82	Test Procedure for Impulse Voltage Tests on Insulated Conductors
IEEE	241	Recommended Practice for Electric Power Systems in Commercial Buildings.

(3) National Fire Protection Association (NFPA). Comply with NFPA 70 requirements for construction, installation and color coding of electrical wire, cable and connections.

(4) National Electrical Manufacturers Association (NEMA). Comply with requirements of the following:

NEMA	WC 3S–19–81	Rubber–Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
NEMA	WC 5S–61–402	Thermoplastic–Insulated Wire and Cable for the transmission and Distribution of electrical Energy
NEMA	WC 7/S–66–524	Cross–Linked–Thermosetting–Polyethylene–Insulated Wire and Cable for the transmission and Distribution of Electrical Energy.
NEMA	WC 8/S–68–516	Ethylene–Propylene–Rubber–Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

(5) Underwriters Laboratory (UL). Provide Material conforming to the following standards

UL	44	Rubber–insulated Wires and Cables
UL	83	Thermoplastic–Insulated Wires and Cables
UL	486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors

UL 854 Service–Entrance Cables

c. Products

(1) Conductors.

For all constant voltage circuits 600 volts or less, provide wire rated 600 V minimum of the single conductor annealed copper type.

Conductors No. 10 AWG and smaller may be solid, and No. 8 AWG and larger shall be stranded.

Conductivity shall not be less than 98 percent at 20°C (68°F) or resistivity greater than 1.7 microhms per centimeter.

For dry and wet locations provide Type THHN/THWN, 75° maximum.

(2) Cable.

For all constant voltage circuits 600 volts or less, provide UL listed cables of sizes, ampacity, temperature ratings and insulating materials as indicated on the drawings. Where no sizes, ampacity, temperature or insulating materials are indicated, use NFPA 70.

(3) Connectors and Splices.

Provide UL listed metal connectors of sizes ampacity temperature ratings, materials, and classes required by NFPA 70 and NEMA standards for applications and services indicated.

For Branch Circuit wires No. 10 AWG and smaller, provide solderless, insulated pressure cable type connectors, 600 V, of the compression or indent type or wire nut connectors. Temperature rating of connectors shall be at least equal to that of the wire on which they are used.

For Branch Circuit wires No. 8 AWG and larger wire, provide socket head cap, hex screw or bolt clamp type connectors, manufactured of high conductivity copper alloy or bronze castings. Select proper connector for each wire size. Retain cable sizes 250 MCM and larger in the connector by twin clamping elements.

(4) Insulating Materials.

Provide plastic electrical insulating tape which is flame retardant, cold and weather resistant. Tape for use in areas subjected to temperatures 40°C, or where the tape will be subjected to an oil splash, use a tape with a minimum thickness of 8.5 mils that consists of an oil–resistant vinyl backing with an oil–resistant acrylic adhesive.

Provide all insulating materials for splices and connections such as glass and synthetic tapes, putties, resins, splice cases, or compositions of the type approved for the particular use, location, voltage and temperature, and apply and install in an approved manner, all in accordance with the manufacturer's recommendations.

(5) Prohibited Products.

The use of non–metallic sheathed cable Types NM to NMC, armored–bushed cable (BX) and armor–clad cable (AC) and service entrance cables (SE and USE) is prohibited.

d. Installation – General.

Deliver wire and cable packaged in factory–sealed containers.

Store wire and cable in a clean dry space in original containers. Protect products form weather, damaging fumes, construction debris and traffic.

Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that the dielectric resistance integrity of wires and cables is maintained.

Unless otherwise indicated in Contract Documents, install all wiring in conduit, in conformance with NFPA 70.

Provide wire, cables and connectors necessary for a complete installation from point of service connection to all receptacles, lighting fixtures, devices, utilization equipment and outlets.

Do not use wire and cable manufactured more than 12 months prior to date of delivery to the site.

Neatly and securely bundle and tie all individual circuits located in branch circuit panelboards, signal cabinets, signal control boards, switchboards and motor control centers, switchboards, motor control centers and pull boxes. Bundle and tie with either marlin twine 2– or 3–ply lacing or nylon straps made of self–extinguishing nylon having a temperature range of –65°F to +350°F. Each strap shall be constructed with a locking hub of head on one end and a taper on the other.

Securely fasten nonferrous identifying tags or pressure sensitive labels to all cables, feeders, and power circuits in vaults, pull boxes, manholes, and at termination of cables. Stamp or print tags or labels to correspond with markings on drawings or marked so that feeder or cable may be readily identified. If suspended type tags are provided, attach them by approximately 55–pound test monofilament line or slip free plastic cable lacing units.

e. Installation – In Conduit.

Refer to L–100–3.2, RACEWAYS, for the preparation of raceways for wire and cables.

Provide suitable installation equipment to prevent cutting and abrasion of conduits during the pulling of wires and cables, according to the following:

(1) Use ropes for pulling of conductors in raceways with existing circuits made of polyethylene or other suitable nonmetallic material.

(2) Pull conductors simultaneously where more than one is being installed in same raceway.

(3) Use pulling compound or lubricant where necessary; compound shall not deteriorate conductor or insulation.

(4) Use lubricants conforming to UL requirement as applicable.

(5) Attach pulling lines to conductor cables by means of either woven basket grips or pulling eyes attached directly to the conductors. Do not use rope hitches.

(6) Where polyethylene insulation is used, a pulling lubricant is required. Use lubricant non–injurious to the insulation.

Install cable supports for all vertical feeders in accordance with the applicable sections of the NFPA 70. Provide cable supports of the wedge type which firmly clamp each individual cable and tighten due to the cable weight.

Install exposed cable parallel and perpendicular to surfaces or exposed structural members and follow surfaces contours, where applicable.

f. Installation – Above Grade.

(1) In making a splice, bring connectors up securely upon the conductors so that all conductors are equally engaged, the insulation is not ruptured, no bare wires are exposed or have "backed off" due to the application of pressure, and the connection will not loosen due to cycling or vibration, in order the insure an efficient splice.

(2) Follow the number, size, and combinations of conductors permitted as listed on manufacturer's packaging.

(3) Fully insulate connectors by a skirt, or taped to provide an insulation value at least equal to the rating of wires being connected.

Tighten electrical connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values or comply with tightening torques specified in UL 486A and 468B.

Color code all secondary service, feeder and branch circuit conductors throughout the project secondary electrical system as follows:

Phase	*208Y/120 Volts*	*240/120*	*480Y/277 Volts*
A	Black	Black	Yellow
B	Red	Red	Brown
C	Blue	—	Orange
Neutral	White	White	Gray
Ground	Green	Green	Green

The colors shall be factory–applied entire length of the conductors by one of the following methods except as noted and limited in the following:

(1) Solid color compound

(2) Solid color coating

(3) Surface printing every 12 inches, maximum spacing of 18 inches.

(4) All grounding and phase conductors No. 10 AWG and smaller shall be solid color compound or solid color coating.

(5) All grounding and phase conductors No. 8 AWG and larger color coded with pressure sensitive tape shall have a background color or shall have field applied color coding methods per UL and NFPA 70.

(6) Apply color pressure–sensitive plastic tape in half overlapping turns for a distance of 6 inches or all terminal points and in all boxes in which splices or taps are made. Apply the last two laps of tape with no tension to prevent possible unwinding.

(7) Use 3/4–inch wide tape in colors as specified.

(8) Do not be obliterated cable identification markings by taping. Tape locations may be adjusted slightly to prevent obliteration of cable markings.

Seal cables and conductors entering from underground between cable and raceway or sleeve, with a waterproof non–hardening sealing compound.

g. Installation – Manholes.

Install and support cables in manholes on steel racks with porcelain or equal insulators. Train cable around manhole walls but do not bend cable to a radius less than the limits in NFPA 70.

Cover constant voltage power cables located in manholes and handholes with arcproof and flameproof tape. Apply the tape in a single layer, one–half lapped, or as recommended by the manufacturer.

h. Installation – Below Grade.

Refer to Specification L-108 for underground cable installations.

Conduct tests with a meggar on constant voltage circuits will be performed so as not to harm the conductor insulation. Follow manufacturer's instructions and Subsection 100–2.12.

100–3.4 CONTROL AND SIGNAL WIRE AND CABLE. Provide control wire, signal wire, and cable at locations indicated on the Drawings and in accordance with the following specifications. Refer to Specification L-108 for underground cable installations.

a. Section Includes.

(1) Class 2 and Class 3

b. Reference Standards.

(1) American Society for Testing and Materials (ASTM). Comply with requirements of the following:

ASTM	B 3	Standard Specification for Soft or Annealed Copper Wire.
ASTM	B 8	Standard Specification for Concentric–Lay–Stranded Copper conductors, Hard, Medium–Hard, or Soft.

(2) Institute of Electrical and Electronics Engineers (IEEE): Comply with the following IEEE Standards:

IEEE	82	Test Procedure for Impulse Voltage Tests on Insulated Conductors.
IEEE	241	Recommended Practice for Electric Power Systems in Commercial Buildings.
Vol. IGA–3		Reducing Electrical Noise in Instruments Circuits.

(3) National Electrical Manufacturers Association (NEMA)/Insulated Cable Engineers Association, Inc. (ICEA): Comply with applicable requirements of the following:

NEMA	WC 3/S–19–81	Rubber–Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
NEMA	WC 5/S–61–402	Thermoplastic–Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
NEMA	WC 7/S–66–524	Cross–linked–thermosetting–Polyethylene–Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.
NEMA	WC 8/S–68–516	Ethylene–Propylene–Rubber–Insulated Wire and Cable for the Transmission and Distribution of Electrical energy

(4) National Fire Protection Association (NFPA): Comply with NFPA 70 requirements for construction, installation and color coding of control and signal sire Class 1, Class 2, and Class 3.

(5) Underwriters Laboratories, Inc. (UL): Provide material conforming to the following UL Standards:

UL	44	Rubber–Insulated Wires and Cables.
UL	83	Thermoplastic–insulated Wires and Cables.
UL Labeled:		Provide control and signal wire UL listed and labeled.

c. Products.

Provide control and signal wires and cables single conductor and multiple conductors, shielded and unshielded, as indicated in the Contract Documents.

Wires and cables shall have 75°C rating minimum, designed to provide a clean signal in a high noise level environment, and suitable to reject static magnetic, common mode and cross talk noise.

Use control and signal wire that is coated copper solid or stranded Class B.

Stranded conductors shall be constructed of short lay seven strand minimum concentric bare copper wires.

Use the size of conductors that is suitable for the current required for satisfactory operation of the apparatus controlled and with proper consideration of circuit's length, unless indicated otherwise in the Contract Documents.

Provide conductors with a primary insulation material that is heat, moisture, flame, and chemical, resistant crosslinked polyethylene, or PVC high temperature insulation material.

Cable shall have nonhydroscopic fillers and a high temperature nonhydroscopic tape shall be applied over the cable code.

Multi–conductor cable shall have conductors color coded.

Control cable for above grade dry locations shall have an outer covering, fabricated of thermoplastic with flame, heat and moisture resisting compounds.

d. Installation.

Deliver wire and cable packaged in factory–sealed containers, or wound on NEMA wire and cable reels. Cable ends shall be sealed with shrinkable self–sealing end caps or by other proper means that protects wires and cables against moisture and dust. Ensure that dielectric resistance integrity of wires and cables is maintained.

Store wire and cable in a clean dry space in original containers. Protect products from weather, damaging fumes, construction debris and traffic.

Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that the dielectric integrity of wires and cables is maintained.

Wire and cables shall be rated for 600 volts minimum. Where the operating voltage is less than 100 volts, the wire and cables may be insulated for 300 volts.

Do not use wire and cable manufactured more than 12 months prior to date of delivery to the site.

Neatly and securely bundle all conductors in signal cabinets and signal control panels. Bundle and cable with nylon straps made of self–extinguishing nylon having a temperature range of –65°F to +350°F.

Provide pressure sensitive labels, securely fastened to each conductor at each termination of single conductor or multiconductor cables. Stamp or print Tags or labels to correspond with markings on the Contract Documents. Mark conductors so they can be readily identified.

Splices in control wire are not permitted. All control wire shall be continuous from terminal block to terminal block.

Prevent pickup of magnetic and static noise by routing cables and wires away form noise sources such as power cables, generators, motors, and any arc producing equipment. Control wiring subject to noise shall be twisted and provided with a total coverage grounded shield.

Prevent cables and wires from picking up common mode noise by grounding the shield at one point. Locate the ground point at the point where the instrument circuit is grounded and isolated from all other grounds.

Prevent pickup of cross talk noise on multiple pair cable by using cables with individually shielded, isolated pair shields.

100–3.5 ELECTRICAL BOXES AND FITTINGS. Provide electrical box and fittings as shown on the drawings and in accordance with the following specifications.

a. Section Includes.

(1) Outlet boxes

(2) Junction boxes

(3) Pull boxes

(4) Conduit bodies

(5) Bushings

(6) Locknuts

(7) Knockout closures

b. References.

(1) National Electrical Manufacturers Association (NEMA): Comply with applicable requirements of the following.

NEMA	OS 1	Sheet Steel Outlet Boxes, Device Boxes, Covers and Box Supports
NEMA	FB 1	Fittings, Cast Metal Boxes

(2) National Fire Protection Association (NFPA): Comply with NFPA 70, for construction and installation of electrical wiring boxes and fittings.

(3) Underwriters Laboratories Inc. (UL): Comply with applicable requirements of the following.

UL 50	Cabinets and Boxes
UL 514A	Metallic Outlet Boxes
UL 514B	Fittings for Conduit and Outlet Boxes, Flush–Device Boxes and Covers
UL 886	Outlet Boxes and Fittings for Hazardous (Classified) Location.

c. Products

Provide galvanized or other approved corrosion resistant finish for all boxes, accessories and fittings.

Provide minimum 4–inch square by 1–1/2–inch deep, one piece, deep–drawn, galvanized steel outlet boxes for general use. Provide 4–inch octagonal concrete boxes and hung ceiling boxes of the folded or welded type where required by project conditions. Construct with stamped knockouts in the back and sides. Provide threaded screw holes with corrosion–resistant screws for securing box covers and wiring devices.

Provide interior outlet box accessories as required for each installation, including covers, mounting brackets, hangers, extension rings, cable clamps, and metal straps for supporting outlet boxes, which are compatible with outlet boxes being used and fulfilling requirements of individual wiring situations.

Provide corrosion–resistant cast–metal weatherproof outlet boxes, of types, shapes and sizes, with threaded conduit ends, cast–metal face plates with spring–hinged waterproof caps suitable configured for each application, including face plate gaskets and corrosion–resistant fasteners.

For Junction and Pull Boxes, provide galvanized sheet steel junction and pull boxes, with screw–on covers and of types, shapes and sizes, to suit each respective location and installation. Provide welded seams and stainless steel nuts, bolts, screws, and washers. Where necessary for boxes to provide a rigid assembly, provide integral structural steel bracing.

Provide galvanized cast–metal conduit bodies, of types, shapes, and sizes, to suit respective locations and installation, construct with threaded–conduit–entrance ends, removable covers, and corrosion–resistant screws.

Provide corrosion–resistant punched–steel box knockout closures, conduit locknuts, malleable iron conduit bushings and offset connectors of types and sizes to suit respective uses and installation.

Provide boxes UL listed for the particular type and class for Hazardous Locations.

Provide outlet boxes conforming to UL 886 for hazardous locations and install in conformance with NFPA 70 Articles 500 through 555 for Hazardous Locations.

d. Installation.

Coordinate installation of electrical boxes and fittings with wire/cable and raceway installation work.

Provide weatherproof outlets for all interior and exterior locations exposed to weather or moisture.

Provide knockout closures to cap unused knockout holes where blanks have been removed.

Provide boxes of sizes adequate to meet NFPA 70 volume requirements, but in no case smaller than sizes indicated in the Contract Documents.

When the mounting height of a wall–mounted outlet box is shown on the drawings, it is defined as the height from the finished floor to a finished grade, to the horizontal center line of the cover plate. Where mounting heights are not indicated or where heights and locations interfere with mechanical, architectural or structural features, install outlet boxes as approved by the Engineer.

Mount outlet boxes for switches with the long axis vertical. Mount boxes for receptacles either vertically or horizontally but consistently one way. Mount three or more gang boxes with the long axis horizontal. Do not use sectional (gangable) boxes, device plates as covers for boxes in exposed locations, or round boxes where conduit must enter box through side of box.

Protect outlet boxes to prevent entrance of debris. Thoroughly clean foreign material from boxes before conductors are installed.

At the following locations use threaded hub type boxes with gasketed weatherproof covers:

(1) Exterior locations.

(2) Where exposed to moisture laden atmosphere

(3) Where indicated in the Contract Documents.

For installation of junction and pull boxes, conform to the following:

(1) For boxes exposed to rain or installed in wet locations use NEMA 4 stainless steel.
(2) Conductors larger than 3/0 in any pull or junction box including equipment grounding conductors shall not exceed the sizes in Table 1.

TABLE 1. CONDUCTORS

SIZE OF LARGEST CONDUCTORS	*MAXIMUM NUMBER OF CONDUCTORS*
No. 4/0 AWG	30
250 MCM	20
500 MCM	15
Over 500 MCM	10

Provide each box with sufficient clamps, grids, or devices to which cables are secured in neat and orderly fashion permitting ready identification and so that no cable will have an unsupported length of more than 30 inches.

100–3.6 WIRING DEVICES. Provide wiring devices at locations indicated on the Drawings and in accordance with the following Specifications.

a. Section Includes.

(1) Receptacles.

(2) Ground–fault circuit interrupters.

(3) Switches.

(4) Photocells.

b. References.

(1) American National Standards Institute (ANSI): Provide plugs and receptacle devices constructed in accordance with ANSI C73, "Attachment Plugs and Receptacles."

(2) Institute of Electrical and Electronics Engineers (IEEE): Construct and install wiring devices in accordance with requirements of IEEE 241, "Recommended Practice for Electric Power Systems in Commercial Buildings."

(3) National Electrical Manufacturers Association (NEMA): Provide wiring devices constructed and configured in accordance with the requirements of:

NEMA	WD 1	General Requirements for Wiring Devices.
NEMA	WD 2	Semiconductor Dimmers for Incandescent Lamps.
NEMA	WD 6	Wiring Devices – Dimensional Requirements

(4) National Fire Protection Association (NFPA): Comply with NFPA 70, as applicable to construction and installation of electrical wiring devices.

(5) Underwriters Laboratories, Inc. (UL): Provide wiring devices which are UL listed and comply with the requirements of:

UL	5	Surface Metal Raceways and Fittings
UL	20	General–Use Snap Switches
UL	498	Attachment Plugs and Receptacles.
UL	514A	Metallic Outlet Boxes
UL	514B	Fittings for Conduit and Outlet Boxes.
UL	943	Ground–Fault Circuit Interrupters.

c. Products.

Provide factory–fabricated wiring devices, in types, colors, and electrical ratings for applications indicated in the Contract Documents. Provide devices and wall plates. Submit color selections for approval by Engineer.

Provide specification grade single and duplex receptacles, 2–pole, 3–wire grounding, with green hexagonal equipment ground screw, ground terminals and poles internally connected to mounting yoke, 20 A, 125 V, with metal plaster ears, design for side wiring with four captively held binding screws and provisions for back wiring with NEMA configuration 5–20R unless otherwise indicated in the Contract Documents.

Provide feed–through type ground fault circuit interrupters, with duplex receptacles, capable of protecting connected downstream receptacles on single circuit, and installed in a 2–3/4 inch deep outlet box without adapter. Provide grounding type UL rated Class A, Group 1. rated 20 A, 125 V, 60 Hz, solid–state ground fault sensing and signaling with 5 milliamperes ground fault trip level, equip with NEMA configuration 5–2OR.

Provide weatherproof single and duplex receptacles, 20A, 125 V, NEMA 5–20R in cast metal box with gasketed, weatherproof cast metal cover plate and gasketed cap over each receptacle opening. Provide cap with spring hinged cover flap.

Provide specification grade, general duty flush single pole 3–way and 4–way toggle and key operated AC quiet snap switches, 20 A, 120–277 V, with mounting yoke insulated from mechanism, equip with plaster ears, switch handle and back or side–wired screw terminals. Provide captive or terminal type terminal screws not smaller than No. 8. Provide back–wired devices with separate access holes for wiring. The Engineer will select the color.

Provide switches for hazardous locations that meet all requirements of NFPA 70 for Class 1, division 1. Provide covers with a finish to match the housing for surface mounted units.

Provide wall plates for each switch, receptacle, signal special purpose outlet. Do not use sectional gang plates. Provide multi–gang outlet plates for multi–gang boxes. Use wall plates in accordance with UL 514A, UL 514B, and UL 514C.

Provide 0.04 inch satin finished steel in all unfinished areas and mechanical spaces. Match the finish of fastening crews with the plates. Provide plates for exposed screw jointed fittings that match the fittings with edges of plates flush with edges of fittings and made of heavy cadmium plated steel. Provide plates for finished areas subject to wet or rain as directed by the Engineer.

For FAA approved lighting and NAVAIDS, provide FAA required photocells with (2) N.O. 20 amp contacts, surge protection, energizing at 35 foot candles and de-energizing at 60 foot candles, in cast aluminum enclosure. For all other lighting provide quick–response, cadmium–sulfide type photocell with 15 to 20 second built–in time delay to prevent response to momentary lightning flashes, car headlights or cloud movements. Photocell will energize when north sky light decreases to 1.5 foot candles and will remain energized until north sky light increases from 3 to 5 footcandles. Provide photocells of voltage and wattage ratings as indicated in the Contract Documents.

d. Installation.

Handle wiring devices carefully to prevent damage. Do not install damaged wiring devices.

Store wiring devices in a clean and dry place. Protect from dirt, construction debris, and physical damage.

Install wiring devices as indicated, in accordance with manufacturer's written instructions, and in accordance with recognized industry practices to fulfill project requirements. Where not indicated, mount switch adjacent to latch jamb of door.

Coordinate with other Work, including painting, electrical boxes and wiring Work, as necessary to integrate installation of wiring devices with other Work.

Install wiring devices only in electrical boxes which are clean; free from building materials, dirt, and debris.

Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for wiring devices. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL 486A, "Wire connectors and Soldering Lugs for Use with Copper Conductors."

Install switches with centerline located 4 feet above finished floor unless otherwise indicated. Install receptacles in machine with centerline 4 feet above finished floor. Locate all other devices as indicated in the Contract Documents or as direct by the Engineer.

Test wiring devices for electrical continuity, and for short–circuits prior to energizing circuitry. Ensure proper polarity of connections is maintained.

100–3.7 CABINETS AND ENCLOSURES. Provide covers, cabinets, and individual hinged–door enclosures for all electrical systems as indicated on the Drawings and in accordance with the following Specifications.

a. References.

(1) National Electric Manufacturers Association (NEMA). Comply with NEMA 250, "Enclosures for Electrical equipment 1000 Volts Maximum."

(2) National Fire Protection Association (NFPA). Comply with NFPA 70, "National Electrical Code" for application, and installation of electrical cabinets and enclosures.

(3) Underwriters Laboratories, Inc. (UL). Provide electrical cabinets and enclosures which are UL listed and labeled, and constructed in conformance with UL 50 "Cabinets and Boxes."

b. Products.

Provide cabinets and enclosures as follows:

(1) Surface NEMA 1 Cabinets and Enclosures:

(a) Provide a front consisting of a one– piece sheet steel frame and a hinged door with catch and lock.

(b) Provide each cabinet with a combination catch and flat key lock.

(c) Hinge doors directly to cabinet, with 3/4–inch flange around all edges shaped to cover edge of box.

(2) Surface NEMA 12 Cabinets and Enclosures:

(a) Fabricate of minimum 16 MSG steel with continuous welded seams.

(b) Provide removable doors, with neoprene door gasket attached with oil–resistant adhesive, and held in place with steel retaining strips. Provide removable internal mounting panel for component installation.

(c) Provide multiple doors where required. Individual door width shall be no greater than 24 inches.

(d) Provide butt hinges or continuous hinges.

(e) Furnish single door cabinets with padlock and hasp, and double door cabinets with 3–point handle–operated–latch plus hasp.

(3) Surface NEMA 4 Cabinets and Enclosures:

(a) Provide features similar to those for NEMA 12 units except provide NEMA 4 protection against hose directed water. Provide multiple cover clamps instead of handle latches. Provide doors over 36 inches in height with vault handle and a 3–point catch, arrange to fasten door at top, bottom, and center.

Paint all cabinets and enclosures located in dry locations, unless noted otherwise in the Contract Documents.

In addition to a priming coat, give all outside surfaces of trim and doors a factory finish coat of gray paint. All cabinet interiors and panel mounted back plates shall be white.

NEMA 4 stainless cabinets and enclosures shall maintain a natural finish.

Provide cabinets and enclosures with provision for cabinet grounding without penetrating exterior wall of the enclosure.

c. Installation.

Touch up all scrapes and other mars in the enclosure finish equal to the manufacturer's finish.

Mount cabinets at a uniform height, nominally 6 feet 6 inches to the top of the enclosure above finished floor, except as otherwise noted in the Contract Documents.

Support and fasten all cabinets securely in place.

100–3.8 SUPPORTING DEVICES. Provide all electrical supports, anchors, sleeves, seals, fastenings and other components indicated on the drawings and in accordance with the following specifications.

a. Section Includes.

(1) Clevis hangers.

(2) Riser clamps.

(3) C–clamps.

(4) One–hole conduit straps.

(5) Two–hole conduit straps.

(6) Round steel rods.

(7) Expansion anchors.

b. References.

(1) National Fire Protection Association (NFPA). Comply with NFPA 70 as applicable to construction and installation of electrical supporting devices.

(2) Underwriters Laboratories, Inc (UL). Conform to UL listings and labeling.

c. Products.

Provide supporting devices with manufacturer's standard materials, designed and constructed in accordance with published product information.

Provide all supports, support hardware and fasteners hot dipped galvanized for exterior installations and cadmium plated for interior installations.

Provide manufactured standard supports including clevis hangers, risers clamps, conduit straps, threaded C–clamps with retainers, wall brackets and spring steel clamps.

Provide U–channel strut system for mounting and supporting electrical equipment. Fabricate strut from 16–gauge hot–dip galvanized steel sheet, 9/16–inch diameter holes, 8–inches on center on top surface. Use fittings that are compatible with the U–channel struts.

d. Installation.

Install hangers, sleeves, seals, U–channel supports and fasteners as indicted and in accordance with manufacturer's written instructions. Comply with requirements of NFPA 70 and American National Standards Institute (ANSI)/National Electrical Manufacturers Association (NEMA) for installation of supporting devices.

Coordinate with other electrical work, including raceway and wiring work.

Provide raceway structural support capacity equal to the maximum weight of the raceway plus a safety factor of 200 pounds. Provide additional support strength where required to prevent distortion of raceway during wire pulling.

Provide individual and multiple (trapeze) raceway hangers, and riser clamps to support raceways. Provide U–bolts, clamps, attachments, and other hardware for hanger assembly, and for securing hanger rods and conduits.

Arrange for grouping of parallel runs of horizontal raceways to be supported together on trapeze type hangers where possible.

Support individual horizontal conduits and EMT 1–1/2 inch size and smaller by either one or two hole pipe straps or separate pipe hangers. Use separate pipe hangers for larger sizes. Spring steel fasteners may be used instead of pipe straps or hangers for sizes 1–1/2–inch and smaller in dry locations. For hanger rods with spring steel fasteners, use a minimum 1/4–inch diameter or larger

threaded steel to meet the safety factor. Use steel fasteners that are specifically designed for supporting single conduits or EMT. Do not use wire as a means of support.

Space supports for metallic raceways in accordance with the requirements or this Section and the requirements of the NFPA 70, except as otherwise indicated.

In vertical runs provide such support that the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports, with no weight load on raceway termination or conductor terminals.

Provide supports for all miscellaneous electrical components as required to produce the same safety allowances as specified for raceway supports previously mentioned. Provide metal channel racks for mounting cabinets, panelboards, disconnects, control enclosures, pull boxes and junction boxes.

Install cable supports in strict compliance with manufacturer's instructions. Spacing should not exceed NFPA 70 tabulation for spacing of conductor supports. Allow adequate slack in conductors to prevent any stress on terminations. Consider conductor thermal expansion and contraction in installation.

Securely fasten all electrical items and their supporting hardware including, but not limited to, conduits, raceways, cables, busways, cabinets, boxes, switches, and control components to a building structure, or structural fixture, unless otherwise indicated.

Fasten by means of round head full threaded hood screws on wood; by toggle bolts on hollow masonry units; by concrete inserts or expansion bolts on concrete or brick; by machine screws; welded threaded studs, or spring–tension clamps on steel work. Threaded studs driven in by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts. Do not weld conduits or pipe strap inserts or steel structures. In partitions of light steel construction use sheet metal screws.

Holes cut to a depth of more than–1/2 inches in reinforced concrete or to a depth of more than 3/4–inch in concrete joints shall not cut the main reinforcing bars. Fill holes that are not used.

On loads applied to any fastener do not exceed one–fifth of the proof test load. Use vibration and shock–resistant fasteners, where applicable.

Rawl plugs are not permitted.

100–3.9 ELECTRICAL IDENTIFICATION. Provide electrical identification as indicated on the drawings and in accordance with the following Specifications.

a. Section Includes.

(1) Buried electrical line warnings.

(2) Identification of electrical power, control and communication, cables and conductors.

(3) Operational instruction signs.

(4) Warning and caution signs.

(5) Equipment labels and signs.

b. References.

(1) American National Standards Institute (ANSI). Comply with requirements of ANSI A13.1, "Scheme for the Identification of Piping Systems" with regard to type and size of lettering for raceway and cable labels.

(2) National Fire Protection Association (NFPA). Comply with NFPA 70, "National Electrical Code" requirements for identification and for provision of warning and caution signs for wiring and equipment.

c. Products.

Provide manufacturer's standard products of categories and types required for each application, except as otherwise indicated.

Use pre-printed, flexible, self-adhesive marking labels for raceways with a legend indicating voltage and service. Size: 1–1/8 inches high by 4 inches long for raceway 1–inch diameter and less, 1–1/8 inches high by 8 inches long for raceway over 1–inch diameter. Color: Black legend on orange background.

Use permanent bright-colored continuous-printed plastic Underground Line Marking Tape compounded for all direct–burial signal and communication circuits; not less than 6 inches wide by 4 mils thick. Provide printed legend indicative of general type of underground line below.

Use Vinyl or Vinyl Cloth Wire/Cable Designation Tape Markers that are self adhesive wrap–around cable/conductor markers with pre–printed numbers and letters for designation purposes.

Cut Aluminum Wrap–Around Cable Marker Bands from 0.014–inch thick aluminum sheet and fitted with slots or ears for securing permanently around wire or cable jacket or around groups of conductors. Provide for legend application with stamped letters or numbers.

Engraved Plastic–Laminate Labels, Sign and Instruction Plates shall be engraving stock melamine plastic laminate, 1/16–inch minimum thickness for up to 20 square inch sign or 8–inch length; 1/8 inch thickness for larger sizes. Engrave legend in white letters on black face and punch for mechanical fasteners.

Use Baked Enamel Warning and Caution Signs that are pre–printed aluminum signs appropriate to the location, punched for fasteners, and sized for good visibility.

Use Fasteners for Plastic Laminate and Metal Signs that are self tapping stainless steel screws or No. 10/32 minimum stainless steel machine screws with nuts and flat and lock washers.

Use Cable Ties that are fungus–inert, self–extinguishing, one piece, self locking nylon cable ties, 0.18 inch minimum width, 50 pounds minimum tensile strength and suitable for a temperature range from –50°F to +350°F. Provide ties in specified colors when used for color coding.

d. Installation.

Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations, specified or indicated in the Contract Documents. Provide numbers, lettering and wording as approved in submittals, as required by code, or as recommended by manufacturers.

Install products covered by this Section where indicated on drawings or specified. Install products covered by this Section where required by NFPA 70, whether or not otherwise indicated. Install products in accordance with manufacturer's written instructions and requirements of NFPA 70.

Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.

In all areas where inside circuits are routed from a vault through an inhabited space, identify all exposed high voltage feeder conduits (over 600 volts) by words "DANGER–HIGH VOLTAGE" in black letters 2 inches high, stenciled on adhesive labels at 10–foot intervals over continuous painted orange background applied as follows:

(1) On entire floor area directly above conduits running beneath and within 12 inches of basement or ground floor in contact with earth or framed above unexcavated space.

(2) On wall surfaces directly exterior to conduits run concealed within the wall.

(3) On all accessible surfaces of concrete envelope around conduits in vertical shafts exposed at ceilings or concealed above suspended ceilings.

(4) On entire surface of exposed conduits.

(5) Clean surface of dust, loose material and oil films before painting.

(6) Prime unpainted surfaces. For galvanized metal use single component acrylic vehicle coating formulated for galvanized surfaces. For concrete masonry units use heavy duty acrylic resin block–filler. For concrete surfaces use clear alkali–resistant alkyd binder type sealer.

(7) Provide one intermediate and one finish coat of orange silicone alkyd enamel.

(8) Apply all primer and finish materials in accordance with manufacturer's instructions.

Identify Pull and Connection Boxes with pressure sensitive, self–adhesive labels indicating system voltage in black pre–printed on orange background as required by NFPA 70 for caution signs on all electrical power and lighting system boxes. Install on the outside

of the box cover. Also label box covers to identify the circuits. Use pressure sensitive plastic labels at exposed locations and similar labels or plasticized card stock tags at concealed boxes.

During backfilling of the trench for each exterior underground communications and control circuit, install continuous underground–type plastic line marker, located directly above line at 6 to 8 inches below finished grade. Where multiple lines are installed in a common trench or concrete envelope and do not exceed and overall width of 16 inches, install a single line marker.

Provide identifying metal tags or aluminum wrap–around marker bands securely fastened to all power circuit cables, feeders, and power circuits in electrical equipment rooms, pull boxes, junction boxes, manholes and hand holes with tags or bands with 1/4–inch steel letter and number stamps with legend to correspond with designations on drawings. If metal tags are provided, attach them with approximately 55–pound test monofilament line or one piece self–locking nylon cable ties.

Tag or label conductors as follows:

(1) Tag or label all conductors with identification indicating source and circuit numbers.

(2) Where Multiple branch circuits or control wiring or communications/signal conductors are present in the same box or enclosure, label each conductor or cable. Provide legend indicating source, voltage, circuit number as applicable. For control and communications/signal wiring, use wire/cable marking tape at terminations and at all intermediate locations where conductors appear in wiring boxes, troughs and control cabinets. Use consistent letter/ number conductor designations throughout on wire/cable marking tapes.

(3) Match identification markings with designations used in panelboards, shop drawings, contract documents and similar previously established identification schemes for the facility electrical work.

(4) Where required by NFPA 70, to ensure a safe operation and maintenance of electrical systems and of the items to which they connect, install warning, caution or instruction signs. Where instructions or explanations are needed for system or equipment operation, provide engraved plastic laminated instruction signs with approved legend. For outdoor items provide butyrate signs with metal backing.

(5) For emergency instructions or other emergency operations, provide engraved laminated signs with approved white legend on red background with minimum 3/8–inch high lettering.

Provide sign or stenciled legend to identify equipment concealed behind bolted covers of housing for disconnecting switches, transformers and switchboards.

Stencil or provide an equipment identification label of engraved plastic–laminate of each major unit of electrical equipment; including central or master unit of each electrical system. This includes communication /signal systems, unless a unit is specified with its own self–explanatory identification. Except as otherwise indicated, provide a single line of text, and a minimum 1 inch high lettering. Engraved labels shall be 2 inches high black lettering in white field. Provide text that matches terminology and numbering of the contract document and shop drawings. Provide label for each unit of the following categories of electrical work:

(1) Panelboards, electrical cabinets and enclosures.

(2) Access doors and panels for concealed electrical items.

(3) Electrical switchgear and switch boards.

(4) Regulators.

(5) Power transfer equipment.

(6) Contactors.

(7) Remote controlled switches.

(8) Control devices.

(9) Transformers.

(10) Power generating units.

For panelboards, provide circuit schedules with explicit description and identification of items controlled by each individual breaker.

Stencil and install labels at locations for best convenience of viewing without interference with operation and maintenance of equipment.

100–3.10 SECONDARY GROUNDING. Provide secondary grounding as indicated on the Drawings and in accordance with the following Specifications.

a. Section Includes.

(1) Materials and methods for grounding constant voltage 600V or less electrical systems only.

(2) Grounding conductors.

(3) Bonding jumpers.

(4) Ground bus.

(5) Ground rods.

(6) Grounding terminations.

b. References.

(1) American National Standards Institute (ANSI). Comply with the requirements of ANSI C2 National Electric Safety Code.

(2) American Society for Testing and Materials (ASTM). Comply with the requirements of ASTM B1 Standard Specification for Hard–Drawn Copper Wire.

c. Products.

Provide insulated equipment grounding conductors that run in the same raceway with circuit wires.

Provide bare ground conductors for grounding of transformers, switch gear, other service equipment, grounding service poles and electrical equipment structures both underground and above ground. Conductors shall be stranded copper conductors.

Provide braided copper tape constructed of No. 30 gauge bare copper wires sized to suit the application.

Ground rods are as indicated by the Contract Documents and NFPA 70. All rods shall have a hard, clean, smooth continuous surface throughout the entire length of the rod.

Where welded connections are required, such welds shall be made by the exothermic process utilizing factory provided molds.

d. Installation.

Deliver grounding materials in factory–sealed containers and with conductors wound on National Electrical Manufacturers Association (NEMA) wire and cable reels.

Store grounding materials in a clean dry space in original containers. Protect products from weather, damaging fumes, construction debris, and traffic.

Supplement the grounded neutral of the secondary distribution system with an equipment grounding system to properly safeguard equipment and personnel. The system shall, as a minimum, comply with NFPA 70.

Provide the equipment grounding system so that all metallic structures, enclosures, raceways, junction boxes, outlet boxes, cabinets, frames, portable equipment, and other conductive items in close proximity with electrical circuits operate continuously at ground potential and provide a low impedance path for possible ground fault currents.

In bus installations other than UL listed assemblies, provide where indicated, a bare copper ground bus spaced 1 inch from the wall and not more than 6 inches above the finished floor in each electrical equipment area. The required length of the ground bus shall be as shown in the Contract Documents. Connect the ground bus by utilizing hard–drawn copper conductors and make connections between the conductors and the ground bus with connectors UL listed for the application.

Drive electrical system ground rods until the top is 6 inches below the final grade.

Interconnect the electrical system ground rods with bare copper grounding electrode conductors buried at least 24 inches below grade.

Size all required equipment grounding and grounding electrode conductors and straps in compliance with NFPA 70. Provide insulated equipment grounding and grounding electrode conductors of the same type and class for the associated phase and neutral conductors of the secondary distribution system.

Provide the proper number and size of pressure connectors required for all equipment grounding bars in panelboards and other electrical equipment for the termination of equipment grounding conductors. Provide pressure connectors for all active and spare circuits.

Where metallic conduits terminate at a metallic housing without mechanical connection, such as locknuts and bushings, provide each conduit with a ground bushing. Connect each ground bushing with a bare copper bonding jumper to the ground lug or bus in the electrical equipment. Size the conductor as required by NFPA 70.

Make all ground connections with UL listed products.

Where an insulated ground wire is connected to ground rods below grade or in wet locations, insulate the connection and seal against moisture penetrating under the insulation.

100–3.11 PANELBOARDS. Provide panelboards as indicated on the drawings and in accordance with the following Specifications.

a. Section Includes.

(1) Distribution panelboards.

(2) Lighting and appliance branch circuit panelboards.

b. Section Does Not Include.

(1) Switchboards.

(2) Service entrance equipment.

c. References.

(1) National Electrical Manufacturers Association (NEMA). Provide panelboards and switches constructed and configured in accordance with the following:

NEMA	AB 1 Molded Case Circuit Breakers and Molded Case Switches
NEMA	KS 1 Encloses Switches
NEMA	PB 1 Panelboards

(2) National Fire Protection Association (NFPA). Conform to the requirements of NFPA 70.

(3) Underwriters Laboratories, Inc. (UL): Construct panelboards in accordance with the following UL publications:

UL	50	Cabinets and Boxes
UL	67	Panelboards
UL	310	Electrical Quick–Correct Terminals
UL	486A	Wire Connectors and Soldering Lugs for Use with Copper Conductors
UL	489	Molded–Case Circuit Breakers and Circuit–Breaker Enclosures
UL	943	Ground–Fault Circuit Interrupters
UL	1053	Ground–Fault Sensing and Relaying Equipment

d. Products.

(1) Distribution Panelboards.

Provide panelboards with buses constructed of solid copper, minimum conductivity 98 percent and rectangular shape.

(a) Mechanically mount and brace buses in conformance with UL 67.

(b) Provide solderless lugs for copper cable.

(c) Provide ampacity as indicated on the drawings.

Provide bare, uninsulated copper, factory installed grounding bus with ampacity equal to the main bus. Provide copper pressure connected terminations.

Provide bus bar connections to branch circuits of the sequenced phased type.

(a) Mount in accordance with UL 67.

(b) Provide numbered terminals.

(c) Provide pressure connectors for copper.

Where words similar to "space", "space only", "future space", or similar wording are used on the drawings and panel schedules, provide bus space for future overcurrent devices.

(a) Extend buses full size.

(b) Brace and insulate bus in accordance with UL 67.

(c) Provide bolted connections for future overcurrent devices.

Construct enclosures in accordance with UL 50 except modify as hereinafter specified.

(a) Construct of minimum 16–gauge galvanized steel NEMA 1, unless indicated otherwise in the Contract Documents.

(b) Conform to UL 67 for additional enclosure requirements.

(c) Provide inner and outer door with hinged trim.

(d) Panelboard, back–box and front plate produced from one manufacturer. Factory fit components before shipment.

(e) Provide enclosure type in conformance with UL 50 and NEMA PB 1.

(f) Provide removable front plates of the dead–front type with removable, and flush hinged enclosure door.

(g) Provide a keyed lock for circuit breaker access cover.

Provide multiple knockouts not fewer than 1.5 times the number of bus circuits.

In addition to the priming coat, all inside and outside surfaces of trim and doors shall be given a factory finish coat of gray paint. Paint recessed boxes, and surface boxes in vaults, switchgear rooms and electrical equipment enclosures as previously described.

Provide factory printed directories with a clear plastic directory cover and metal frame attached to the panel door.

Provide Wiring Space that conforms to the requirements of UL 67. Feed–through gutters are not permitted.

(a) Conform to NFPA 70 for maximum gutter fill.

(b) Conform to UL 67 for minimum width of gutter and wire bending space.

Breakers shall have inverse time automatic tripping.

Provide adjustable trip circuit breakers as noted in the Contract Documents.

Use factory assembled bolt-in type circuit breakers, except breakers 225 amperes frame size and larger may be plug–in type if held in place by positive locking device requiring mechanical release for removal.

Integrally fused circuit breakers with inverse time automatic tripping, and fuses shall conform to UL 198B, 198C, 198D, 198E, 198F, 198G, 198H, 198L, and 198M.

Provide breakers as indicated in the Contract Documents with current interrupting ratings, in RMS symmetrical amps.

(2) Lighting and appliance Branch Circuit Panelboards.

Provide enclosures, bus systems, spacing and knockouts same as for distribution panelboards.

Provide interrupting ratings, circuit arrangements, and trip settings as noted in the Contract Documents.

Provide common trip mechanisms for multi–pole breakers.

Provide instantaneous automatic trips conforming to NEMA AB 1.

Breakers shall be bolt–on type, factory assembled.

Stab–in circuit breaker types are not acceptable.

Provide quick–make and quick–break mechanism.

e. Installation.

Install panelboards in conformance with NEMA PB 1 and NFPA 70.

Torque lug screws in accordance with UL 486A for copper conductors and UL 486B for aluminum conductors. Install connectors, lugs, neutral bus and other field installed components in accordance with manufacturer's published literature.

Verify gutter size conforms to wire bending space requirements of NFPA 70 and UL 67.

Wire wrap branch circuits in gutters after installation. Use approved wire ties.

Verify maximum gutter fill to conform with NFPA 70 and UL 67.

Verify bolted circuit breaker connection lugs conforming to shop drawings.

Verify breaker size, trip setting, and breaker type in conformance with Contract Documents.

Complete typewritten panelboard circuit directory prior to project acceptance.

Only wires made of the conductor material for which the panelboard terminals have been marked shall be used.

Adjustable Trip Settings. Install lugs and ground connectors in conformance with UL 486A and UL 486B. Verify factory settings for adjustable trip breakers. Field adjust in conformance with manufacturer's recommendations, if necessary.

100–3.12 OVERCURRENT PROTECTIVE DEVICES. Provide overcurrent protective devices as indicated on the drawings and according to these specifications.

a. Section Includes.

(1) Molded case circuit breakers.
(2) Heavy duty safety switches.
(3) Combination molded case circuit breakers and current–limiting fuses.

b. Section Does Not Include.

(1) Main service switches.

c. References.

(1) National Electrical Manufacturers Association (NEMA). Provide and install fuses and circuit breakers conforming to NEMA, including:

NEMA	AB–1	Molded Case Circuit Breakers and Molded Case Switches.
NEMA	AB–2	Field Inspection and Performance Verification of Molded Case Circuit. Breakers Used in Commercial and Industrial Applications, Procedures for.

NEMA	AB–3	Molded Case Circuit Breakers and Their Application.
NEMA	FU–1	Low Voltage Cartridge Fuses.

(2) National Fire Protection Association (NFPA). Comply with NFPA 70, "National Electrical Code" requirements as applicable to construction and installation of overcurrent devices.

(3) Underwriters Laboratories, Inc. (UL): Provide overcurrent protective devices that are UL–listed and labeled. Provide fuses and circuit breakers conforming to UL including:

UL	512	Fuseholders
UL	198B	Class H Fuses
UL	198C	High–Interrupting–Capacity Fuses, Current–Limiting Types
UL	198D	Class K Fuses
UL	198E	Class R Fuses
UL	198G	Fuses for Supplementary Overcurrent Protection
UL	198H	Class T Fuses
UL	489	Molded–Case Circuit Breakers and Circuit–Breaker Enclosures.

d. Products.

(1) Enclosures shall be NEMA 1, unless otherwise indicated in the Contract Documents. Enclosures shall have an externally operable handle with interlock to prevent opening of front cover with the switch in the "ON" position. Handle shall be lockable in the "OFF" position.

(2) Molded Case Circuit Breakers.

Circuit breakers shall conform to NEMA AB 1.

Use circuit breakers that have a trip rating and number of poles as indicated on the Contract Documents.

Use circuit breakers that have an interrupting current rating equal to or greater than the available fault current at their location in the electrical system, unless otherwise specified. Provide a minimum rating of 10,000 amperes symmetrical, unless a greater rating is shown on the Contract Documents.

Use circuit breakers from the same manufacturer.

Provide circuit breakers with a quick–made and quick–break toggle mechanism with inverse–time trip characteristics.

Automatic release is to be secured by a bimetallic thermal element releasing the mechanism latch.

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 position.

Provide adjustable magnetic trip devices adjusted at the factory to "low" trip setting ampere values.

(3) Heavy Duty Safety Switches.

Provide quick make, quick break load interrupter enclosed knife switch assemblies.

Provide fuses that conform to UL 198B, 198C, 198D, 198E 198F, 198G, 198H, 198L, and 198M. Provide fuses of the sizes noted on the Contract Documents.
Install current–limiting fuses instead of regular fuses where the fault current exceeds 10,000 RMS amperes.

Fuses rated over 600 amperes shall be NEMA Class L.

Fuses for use with switches rated 600 amperes and less shall be UL Class RK–5 or RK–1 as noted, unless otherwise specified. Class RK–5 and RK–1 fuses shall be dual element type with minimum time–delay of 10 seconds at 500 percent of rating.

Provide one complete set of fuses installed for all switches requiring fuses. Provide one spare fuse of each size and type installed.

(4) Combination Molded Case Circuit Breaker and Current–Limiting Fuses.

Where the short circuit current exceeds the interrupting ratings of molded case circuit breakers, provide high–interrupting capacity integral current limiters on the load side of the circuit breakers.

The circuit breaker and limiter combination shall be a coordinated unit meeting the applicable requirements of UL 489, so designed that the normal thermal magnetic overcurrent devices provide coordinated protection against overloads and short circuits up to a predetermined value. The current limiters shall assume the fault–clearing duty and extend short circuit protection up to and including 100,000 RMS amperes.

High–interrupting–capacity circuit breakers adequate for the short circuit current available at the particular location in the system may be provided instead of the combination current limiting fuse units.

d. Installation.

Install overcurrent protective devices as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure that protective devices comply with requirements. Comply with NFPA 70 and NEMA standards for installation of overcurrent protective devices.

Coordinate with other work, including electrical wiring work, as necessary to interface installation of overcurrent protective devices with other work.

Fasten overcurrent devices without causing mechanical stresses, twisting or misalignment being exerted by clamps, supports, or cabling.

Set field–adjustable circuit breakers for trip settings as indicated, subsequent to installation of units.

Install fuses and package the spare fuses in an orderly fashion.

Inspect circuit–breaker operating mechanisms for malfunctioning and, where necessary, adjust units for free mechanical movement.

Prior to energization of overcurrent protective devices, test devices for continuity of circuitry and short–circuits. Correct malfunctioning units, and then demonstrate compliance with requirements.

100–3.13 METHOD OF MEASUREMENT AND BASIS OF PAYMENT. Work specified herein will be measured for payment as part of other Pay Items described in other Specifications. The cost of Work required in this Specification will be included in the prices bid for Pay Items included in the Schedule of Prices.

SPECIFICATION L–101. INSTALLATION OF AIRPORT ROTATING BEACONS L–801A, L–801H, L–801S, L–802A, L–802H, AND L–802S

DESCRIPTION

101–1.1 GENERAL.

a. This Work consists of furnishing and installing Airport Rotating Beacons, including mounting, leveling, conduit wiring, power source, beacon controller, photocell, painting, lightning protection, servicing, and testing of the beacon and all materials and incidentals necessary to place the beacons in operating condition as a completed unit. This Work includes an electric utility service, panelboard, mounting platform and attachment structure if specified in the Contract Documents. This Work does not include a tower structure or tower obstruction lighting.

101-1.2 THIS SPECIFICATION INCLUDES:

a. Regulatory requirements.
b. Beacons.
c. Beacon attachment structure.
d. Lightning rod.
e. Down conductor.
f. Down conductor ground rod.
g. Ground clamp.
h. Paint.

101-1.3 OTHER RELATED SPECIFICATIONS.

a. L-100-2.1 through L-100-2 .17 General Requirements.
b. L-100-3.2 Raceways.
c. L-100-3.3 Feeder and Branch Circuit Wire and Cable.
d. L-100-3.4 Control and Signal Wire and Cable.
e. L-100-3.5 Electrical Boxes and Fittings.
f. L-100-3.6 Wiring Devices.
g. L-100-3.7 Cabinets and Enclosures.
h. L-100-3.8 Supporting Devices.
i. L-100-3.9 Electrical Identification.
j. L-100-3.10 Secondary Grounding.
k. L-100-3.11 Panelboards.
l. L-100-3.12 Overcurrent Protective Devices.

101-1.4 CLASSIFICATIONS.

a. L-801A Medium Intensity Airport Beacon.
b. L-801H Medium Intensity Heliport Beacon.
c. L-801S Medium Intensity Seaplane Beacon.
d. L-802A High Intensity Airport Beacon.
e. L-802H High Intensity Heliport Beacon.
f. L-802S High Intensity Seaplane Beacon.

NOTE TO SPECIFIER:
The Plans need to show a complete installation to further define the scope of Work.

EQUIPMENT AND MATERIALS

101–2.1 REGULATORY REQUIREMENTS.

a. Airport lighting equipment and materials requiring Federal Aviation Administration (FAA) specifications shall have the prior approval of the FAA, and be listed in the latest edition of Advisory Circular (AC) 150/5345–53 Appendix 3.

b. All other electrical equipment and materials shall be subject to acceptance through manufacturer's certification of compliance as required in Specification L–100.

101–2.2 BEACON. The beacon shall meet the requirements of the latest edition of AC 150/5345–12, Specification for Airport and Heliport Beacons.

101–2.3 BEACON ATTACHMENT STRUCTURE. The attachment structure shall be as specified in the Contract Documents. Galvanized steel shall conform to ASTM A242. Wood structure shall be pressure treated conforming to AWPA Treatment C1. All ungalvanized steel shall conform to ASTM A36.

101–2.4 LIGHTNING ROD. The lightning rods shall be 5/8" diameter x 8' long galvanized steel, copper–clad.

101–2.5 DOWN CONDUCTOR. The down conductor cable for lighting protection shall be No. 4 AWG or larger bare stranded copper wire.

101–2.6 DOWN CONDUCTOR GROUND ROD. The ground rod shall be 5/8" x 8' long, copper or copper clad.

101–2.7 GROUND CLAMP. Ground clamp shall be similar and equal to the Type GR as manufactured by the Burndy Engineering Company.

101–2.8 PAINT.

a. Priming paint for ungalvanized metal surfaces and the mixing thereof shall conform to ASTM D 83.

b. Priming paint for galvanized metal surfaces shall be zinc dust–zinc oxide primer paint conforming to Fed. Spec. TT–P–641.

c. Orange paint for the body and the finish coats on metal and wood surfaces shall consist of a ready–mixed non–fading paint meeting the requirements of Fed. Spec. TT–P–59. The color shall be in accordance with Federal Standard 595, Aviation Gloss Orange Number 12197.

d. White paint for body and finish coats on metal and wood surfaces shall be ready–mixed paint conforming to Fed. Spec. TT–P–102.

e. Priming paint for wood surfaces shall be mixed on the job by thinning the above specified orange or white paint with 1/2 pint (0.06 liter) of raw linseed oil to each gallon (liter).

CONSTRUCTION METHODS

101–3.1 PLACING THE BEACON EQUIPMENT. Mount the beacon equipment on a tower, separate structure, or building as shown in the Contract Documents. Install the power source and the electric service utility at the location indicated in the Contract Documents.

101–3.2 HOISTING AND MOUNTING. Place the beacon on the mounting platform using suitable slings and hoisting methods. Before fastening the beacon in place, check the mounting holes for correct spacing. Do not strain or force the beacon base or mounting legs out of position to fit incorrect spacing of mounting holes. Use stainless steel hardware sized by the manufacture for attachment.

101–3.3 LEVELING. After the beacon has been mounted in place, level it accurately. Check the leveling in the presence of the Engineer in accordance with manufacturer's instructions.

101–3.4 SERVICING. Before placing the beacon in operation, accomplish the following:

a. Clean and polish the reflector and all glassware, both inside and outside, using a type of cleaner which will not scratch the finishes.

b Clean interior of beacon base and check for alignment of parts.

c. Clean and polish commutator slip rings. Apply a very small amount of Vaseline to the slip rings and immediately wipe off any excess. Operate about 1/2 hour, then wipe the surplus off the rings again. Remove the brushes and lubricate the chamber of brush holders.

d. Apply grease to the gears of the rotating mechanism where gears are accessible. Use a stiff brush and do not overgrease. Check to see if gears mesh properly, and turn the motor shaft by hand to ascertain if action of gear train is free. Check and adjust the clutch tension. Set

the clutch to release at 12–16 pounds measured at 2 feet. Measure with the scale in a horizontal position tangent to the surface of the housing. Fill grease fittings with grease conforming to the manufacturer's recommendations.

e. Set brushes for free motion on slip rings, and adjust springs to manufacturer's recommendations.

f. Secure lamps properly in the sockets.

101–3.5 BEACON ADJUSTMENT. After the beacon has been mounted and leveled, adjust the elevation of the beams. Make the final beam adjustments at night so that results can be readily observed. Adjust the beams to the elevation as shown in the Contract Documents, except that, in no case shall the elevation of the beams be less than 2 degrees above the horizontal.

101–3.6 BEACON ATTACHMENT STRUCTURE. Where the beacon is to be mounted at a location other than the beacon tower and where a special attachment structure is required, the construction of this structure and hardware shall be in accordance with the details shown in the Contract Documents.

101–3.7 ELECTRICAL. Furnish all necessary labor and materials and make complete above ground electrical connections in accordance with the wiring diagram furnished with the Contract Documents.

Attach all electrical circuits to the beacon controller using the controller terminal blocks. Avoid cable splices.

Furnish and install at the top of the beacon tower or mounting platform a circuit–breaker panel board consisting of breakers to provide separate protection for the circuits to the beacon lamps, motor, obstruction lights, and other equipment. Locate the panel board so that it is accessible from the beacon structure.

Run all exposed wiring in not less than 1/2 inch galvanized rigid steel conduit, or intermediate metal conduit. Do not install conduit across the surface of the beacon platform floor. Install all conduit to provide for drainage. If mounted on a steel beacon tower, fasten the conduit to the tower members with "wraplock" straps, clamps, or approved fasteners. Fasten the conduit to wooden structures with galvanized pipe straps and with galvanized round head wood screws not less than No. 8 nor less than 1–1/4 inches (31 mm) long. Space all conduit straps approximately 5 feet (1.5 m) apart.

101–3.8 LIGHTNING PROTECTION. If down–conductor cables are attached to a tower structure, securely fasten the cables to the surface of the tower leg at 5–foot (1.5–m) intervals with suitable fasteners.

Make all connections of cable to cable, cable to lightning rods, and cable to ground plates or rods, with approved type solderless connectors or noncorrosive metal that are rated the same as the cable.

Firmly attach the down–conductor to the ground plate or rod by means of a ground conductor or clamp.

Accomplish the complete lightning protection installation to the satisfaction of the Engineer. The resistance to ground of any part of the lightning protection system shall not exceed 25 ohms.

101–3.9 PAINTING. If construction of a wooden mounting platform is stipulated in the proposal as part of this Specification, give all wooden parts of the platform one priming coat of white or aviation–orange paint after fabrication but before erection and one body and one finish coat of aviation–orange paint after erection. Give steel mounting platforms one priming coat before erection and one body and one finish coat of aviation–orange paint after erection. Give all equipment installed under this Contract and exposed to the weather one body and one finish coat of aviation–orange or white paint as required. This includes the beacon, beacon base, breaker cabinet, all conduit, and transformer cases. It does not include lightning rods, obstruction light globes, and beacon lenses.

Apply the paint uniformly in the proper consistency by skilled painters. The finished paint shall be free from sags, holidays, and smears. Give each coat of paint ample time to dry and harden before the next coat of paint is applied. Allow a minimum of 3 days for drying on wood surfaces, and allow a minimum of 4 days for drying on metal surfaces. Do not paint in cold, damp, foggy, dusty, or frosty atmospheres, or when air temperature is below 40°F (4°C), nor started when the weather forecast indicates such conditions for the day.

Clean all surfaces before painting. The surfaces should be dry and free from scale, grease, rust, dust, and dirt when paint is applied. Cover all knots in wood surfaces with shellac immediately before applying the priming coat of paint. Fill nail holes and permissible imperfections with putty.

Thin the ready–mixed paint for the priming and body coats in accordance with the manufacturer's recommendations.

101–3.10 TESTING. Test the installation in operation as a completed unit prior to acceptance. These tests shall include operation of the lamp–changer operation and taking meggar and voltage readings. Testing equipment shall be furnished by the Contractor. Conduct tests in the presence of the Engineer.

METHOD OF MEASUREMENT

101–4.1 Beacons will be measured as complete units per lump sum for beacons installed in place, accepted, and ready for operation. Electric Utility Services will be measured as a complete unit per Lump Sum for services provided at location indicated in the Contract Documents.

BASIS OF PAYMENT

101–5.1 Payment will be made at the Contract Price per Lump Sum for the classification of Airport Rotating Beacons, at the locations indicated, complete and accepted.

Payment will be made the Contract Price per Lump Sum for Electric Utility Service, at the locations indicated, complete and accepted.

These prices will be full compensation for furnishing all materials and for all preparation, assembly and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the Work.

a. Airport Rotating Beacons will include the beacon equipment, beacon controller, lightning protection, attachment structure, mounting, leveling, conduit, wiring, power source, photoelectric control, ground rods, and servicing and testing of the beacon, all in accordance with the Contract Documents.

b. The Electric Utility Service will include the utility meter, meter enclosure, main service switch, pull box, photocell contactor or controller, if required, conduit wire, attachment structure, concrete pad, excavation, and backfill, all in accordance with the Contract Documents, and in particular, L-100-3.3 and L-100-2.3

NOTE TO SPECIFIER:
Electric Utility Services are bid separately. The location and number should be shown on the Plans. Connection to power sources other than electric utilities are incidental and are provided from existing electric facilities on the Airport, except cable from the source to the location is measured under L–108.

Standard Pay Items for Work covered by this Specification are as follows:

Pay Item L10101	Airport Rotating Beacon, Location No. ___ L–801A, per Lump Sum
Pay Item L10102	Airport Rotating Beacon, Location No. ___ L–801H, per Lump Sum
Pay Item L10103	Airport Rotating Beacon, Location No. ___ L–801S, per Lump Sum
Pay Item L10104	Airport Rotating Beacon, Location No. ___ L–802A, per Lump Sum
Pay Item L10105	Airport Rotating Beacon, Location No. ___ L–802H, per Lump Sum
Pay Item L10106	Airport Rotating Beacon, Location No. ___ L–802S, per Lump Sum
Pay Item L10107 through L10110	Electric Utility Service, Location No. ___, per Lump Sum

Measurement and Payment will be made only for Pay Items listed in the Schedule of Prices. The cost of all Work required by the Contract Documents will be included in the Pay Items contained in the Schedule of Prices.

MATERIAL REFERENCES

Fed.Spec. TT P-59	Paint, Ready-mixed, International Orange
Fed.Spec. TT P-641	Primer, Paint; Zinc Dust-zinc Oxide
Fed.Spec. TT P-102	Paint, Oil: Exterior, Ready-mixed, White and Light Tints
Fed Std. 595	Colors
AC 150/5345-7	Specification for L-824 Underground Cable for Airport Lighting Circuits
AC 150/5345-12	Specification for Airport and Heliport Beacons

SPECIFICATION L–107. INSTALLATION OF AIRPORT WIND CONES L-806 AND L-807

DESCRIPTION

107–1.1 GENERAL.

a. This Work consists of furnishing and installing an Airport Wind Cone in accordance with these Specifications and in accordance with the dimensions, design, and details shown in the Contract Documents. The Work includes furnishing and installing the wind cone, a support structure for mounting the wind cone, power source, conduit, wiring on the wind cone and wind cone structure, and a concrete foundation. The Work also includes all cable connections, conduit and conduit fittings, furnishing and installation of all lamps, ground rod and ground connection, testing of the installation, and all incidentals necessary to place the wind cone in operation as a completed unit to the satisfaction of the Engineer.

This Work includes an Electric Utility Service and Segmented Circle, if specified in the Contract Documents.

107-1.2 THIS SPECIFICATION INCLUDES:

a. Regulatory Requirements.
b. Wind Cones.
c. Segmented Circle.
d. Paint.

107-1.3 OTHER RELATED SPECIFICATIONS.

a. L-100-1.1 through L-100-2.17 General Requirements.
b. L-100-3.2 Raceways.
c. L-100-3.3 Feeder and Branch Circuit Wire and Cables.
d. L-100-3.4 Control and Signal Wire and Cable.
e. L-100-3.5 Electrical Boxes and Fittings.
f. L-100-3.6 Wiring Devices.
g. L-100-3.7 Cabinets and Enclosures.
h. L-100-3.8 Supporting Devices.
i. L-100-3.9 Electrical Identification.
j. L-100-3.10 Secondary Grounding.
k. L-100-3.12 Overcurrent Devices.

107-1.4 CLASSIFICATIONS.

a. Type L-806 - Low Mass Supporting Structure.
b. Type L-807 - Rigid Mass Supporting Structure.
c. Size 1 - 8-Foot Wind Cone (L-806 and L-807).
d. Size 2 - 12-Foot Wind Cone (L-807).
e. Style 1 - Lighted.
f. Style 2 - Unlighted (Not Used).

NOTE TO SPECIFIER:
Electric utility services are bid as separate Pay Items.
Electric power sources provided from existing airport

EQUIPMENT AND MATERIALS

107–2.1 REGULATORY REQUIREMENTS.

a. Airport lighting equipment and materials requiring Federal Aviation Administration (FAA) specifications shall have the prior approval of the FAA, and be listed in the latest edition of Advisory Circular (AC) 150/5345–53, Appendix 3.

b. All other electrical equipment and materials shall be subject to acceptance through manufacturer's certification of compliance as required in Specification L–100.

107–2.2 WIND CONES. The 8–foot (24 m) and 12–foot (3.5–m) wind cones and assemblies shall conform to the requirements of the latest edition of AC 150/5345–27, Specification for Wind Cone Assemblies.

107-2.3 SEGMENTED CIRCLE. Furnish and install segmented circle markers of the design, type, and at the locations shown in the Contract Documents.

107–2.4 PAINT.

a. Priming paint for ungalvanized metal surfaces, and the mixing thereof, shall conform to ASTM D 83.

b. Use zinc dust-zinc oxide priming paint for galvanized metal surfaces that conforms to Fed. Spec. TT–P–641.

c. Use orange paint for the body and the finish coats on metal and wood surfaces that consists of a ready–mixed nonfading paint meeting the requirements of Fed. Spec. TT–P–59. The color shall be in accordance with Federal Standards 595, Aviation Gloss Orange Number 12197.

d Use ready-mixed white paint for body and finish coats on metal and wood surfaces that conforms to Fed. Spec. TT–P–102.

e. Mix on the job priming paint for wood surfaces by thinning the previously specified aviation–orange or white paint by adding 1/2 pint (0.06 liter) of raw linseed oil to each gallon (liter).

CONSTRUCTION METHODS

107–3.1 INSTALLATION. Mount the Wind Cones on a support role as shown in the Contract Documents. Install the power source and the electric utility service at the locations indicated in the Contract Documents.

107–3.2 ELECTRICAL CONNECTION. Furnish all labor and materials and make complete electrical connections in accordance with the wiring diagram furnished with the Contract Documents.

107–3.3 GROUND CONNECTION AND GROUND ROD. Furnish and install electrical system ground rods, grounding cable, and ground clamps for grounding the unit. The ground rod shall be 5/8_" x 8' long copper or copper clad. The grounding cable shall consist of No. 4 AWG bare stranded copper wire or larger. The resistance to ground shall not exceed 25 ohms.

107–3.4 PAINTING. Apply three coats of paint (one prime, one body, and one finish) to all exposed material installed except the fabric cone, obstruction light globe, and lamp reflectors. Give the wind cone assembly, if painted on receipt, one finish coat of paint instead of the three coats specified herein. The paint shall meet the requirements of Fed. Spec. TT–P–59. The color shall be in accordance with Federal Standard 595, Aviation Gloss Orange Number 12197.

107–3.5 LAMPS. Furnish and install general lighting service lamps as recommended by the manufacturer and necessary to complete the assembly.

107–3.6 CHAIN AND PADLOCK. Furnish and install a suitable operating chain for lowering and raising the hinged top section of Wind Cones. Attach the chain to the pole support in a manner to prevent the light fixture assembly from striking the ground in the lowered position.

When provisions for a padlock are provided by the manufacturer, furnish a padlock for securing the hinged top section to the fixed lower section. Deliver two sets of keys for the padlock to the Sponsor.

METHOD OF MEASUREMENT

107–4.1 Wind Cones, of the type and at the location indicated, and Segmented Circles at locations indicated, will be measured as a complete unit per lump sum. Electric Utility Service will be measured as a complete unit per lump sum for each location required by the Contract Documents.

BASIS OF PAYMENT

107-5.1 Payment will be made at the Contract price per Lump Sum for the classification of Airport Wind Cone, at the locations indicated, complete and accepted.

Payment will be made at the Contract price per Lump Sum for the Electric Utility Service, at the locations indicated, complete and accepted.

Payment will be made at the Contract price per Lump Sum for the Segmented Circle, at the locations indicated, complete and accepted.

These prices will be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the Work.

a. Airport Wind Cone shall include the wind cone equipment, support structure, foundation, receptacle, disconnect switch, pull box mounting, leveling, conduit, wiring, power source, photoelectric control, ground rods, and servicing and testing of the Wind Cone, all in accordance with the Contract Documents.

b. The Electric Utility Service shall include the utility meter, meter enclosure, main service switch, pull box, photocell contactor or controller, if required, conduit wire, attachment structure, concrete pad, excavation, and backfill, all in accordance with the Contract Documents, and in particular L-100-2.2 and L-100-2.3.

c. The Segmented Circle shall include the segmented circle equipment, foundation excavation, and backfill, all in accordance with the Contract Documents.

Standard Pay Items for Work covered by this Specification are as follows:

Pay Item L10701 through L10705	Wind Cone, L-806, Size 1, Style 1, Location No. ___, per lump sum
Pay Item L10706 through L10710	Wind Cone, L-807, Size 1, Style 1, Location No. ___, per lump sum
Pay Item L10711 through L10715	Wind Cone, L-807, Size 2, Style 1, Location No. ___, per lump sum
Pay Item L10716 through L10720	Electric Utility Service, Location No. ____, per lump sum
Pay Item L10721 through L10725	Segmented Circle, Wood Markers, Location No. ____, per lump sum
Pay Item L10726 through L10730	Segmented Circle, Steel Markers, Location No. ____, per lump sum

MATERIAL REFERENCES

Fed.Spec. TT P-59	Paint, Ready-mixed, International Orange
Fed.Spec. TT P-641	Primer, Paint; Zinc Dust-Zinc Oxide
Fed.Spec. TT P-102	Paint, Oil: Titanium Lead Zinc and Oil, Exterior, Ready-mixed, White and Light Tints
Fed Std. 595	Colors
AC 150/5345-27	Specification for Wind Cone Assemblies

SPECIFICATION L–108. INSTALLATION OF UNDERGROUND CABLE AND CONDUCTORS FOR AIRPORTS

DESCRIPTION

108–1.1 GENERAL.

a. This Work consists of furnishing and installing underground cable, conductors, and flexible polyethylene duct in accordance with these Specifications at the locations shown in the Contract Documents. This Work includes excavation and backfill of the trench, installation of cable and counterpoise wire in trench, duct, conduit or by plowing, the location and protection of existing circuits, splicing, cable marking, and testing of the installation, site installation, and all incidentals necessary to place the cable in operating condition as a completed unit.

108-1.2 THIS SPECIFICATION INCLUDES:

a. Regulatory Requirements.
b. Underground Cable.
c Bare Counterpoise Wire.
d. Underground Wire/Cable Connections.

108-1.3 OTHER RELATED SPECIFICATIONS.

a. L-100-1.1 through L-100-2.17 General Requirements.

108-1.5 CLASSIFICATIONS.

a. Type C Cable and Conductors - 600V to 5000V with cross linked polyethylene insulation.

EQUIPMENT AND MATERIALS

108–2.1 REGULATORY REQUIREMENTS.

a. Airport lighting equipment and materials requiring Federal Aviation Administration (FAA) specifications shall have the prior approval of the FAA, and be listed in the latest edition of Advisory Circular (AC) 150/5345–53, Appendix 3.

b. All other electrical equipment and materials shall be subject to acceptance through manufacturer's certification of compliance as required in Specification L–100.

108–2.2 UNDERGROUND CABLE. Underground cable shall conform to the requirements of the latest edition of AC 150/5345–7, Specification for L–824 Underground Electrical Cable for Airport Lighting Circuits.

If telephone control cable is used as control cable, it shall be copper shielded, polyethylene insulated and jacketed, No. 19 AWG telephone cable conforming to the United States Department of Agriculture, Rural Electrification Administration (REA) Bulletin 345–14, REA Specification for Fully Color–Coded, Polyethylene Insulated, Double Polyethylene–Jacketed Telephone Cables for Direct Burial.

Where bare copper counterpoise conductors are to be installed where soil conditions would adversely affect bare copper wire, thermoplastic wire conforming to Fed. Spec. J–C–30, Type TW, 600 volt, may be used.

Cable type shall be Classification Type C. Size, number of conductors, strand and service voltage are specified in the Contract Documents.

108–2.3 BARE COUNTERPOISE WIRE. Bare copper wire for counterpoise installations shall be stranded wire conforming to ASTM Specifications B 3 and B 8.

108–2.4 UNDERGROUND WIRE/CABLE CONNECTIONS. In–line connections of underground cables shall be of the type called for in the Contract Documents, and shall be one of the following types. Series circuit connectors shall conform to the latest edition of AC 150/5345-26.

a. Cast Splice. A cast splice, employing a plastic mold and using epoxy resin equal to that manufactured by Minnesota Mining and Manufacturing (3M) Company, "Scotchcast" Kit No. 82—A, or as manufactured by Hysol Corporation, "Hyseal Epoxy Splice" Kit No. E1135, for potting the splice is approved. The means of splicing telephone control cable is by using 3M "Scotchcart" kits 89–D through 89–D3 or 8981 through 8985 or equal.

b. Vulcanized Splice. A vulcanized splice employing Joy Manufacturing Company's Vulcanizing Kit No. X–1604–8 or equal is approved for field vulcanized splices. Use the proper molds for various cable sizes.

c. Field–attached Plug–in Connector. Use L–823 Plug and Receptacle, Cable Connectors, Class I Type B, employing connector kits, for field attachment to single conductor cable per the Contract Documents.

d. Factory–Molded Plug–in Connector. Specification for L–823 Connectors, Class I, Type A, Factory–Molded to Individual Conductors, are approved.

e. Taped Connections. Taped connections employing field–applied rubber, or synthetic rubber tape covered with plastic tape are approved. Double tape the secondary connector joint. The first layer of tape shall be 3M, #13 rubber tape or equal. The second layer of tape shall be 3M, #38 plastic tape or equal. Lap the second layer of tape over the first layer of tape. In all the above cases, use crimp connectors to make connections of cable conductors utilizing a crimping tool designed, to make a complete crimp before the tool can be removed. No. 19 AWG telephone control wires may be connected by means of wrapped and soldered splice, 3M Company Moisture Proof UR Type Connector, or equal.

CONSTRUCTION METHODS

108–3.1 GENERAL. Install the specified cable at the approximate locations indicated in the Contract Documents.

Locate and mark all existing circuits near the construction of new circuits with flagging through the turf area prior to the excavating operation by the Contractor.

The Contractor is entirely responsible for locating and identifying existing underground cables. Do not, under any circumstances, deliberately plow or trench across existing conductors for the sole purpose of locating cables. Cable that is cut and is not designated for replacement shall be replaced at Contractor's expense in its entirety from edge light unit to unit. Replace home run circuits in their entirety or install a UL or ETL listed pull box for a cast splice, at the Contractor's expense.

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 shown in the Contract Documents.

Acclimate cable to the installed ambient temperature before installation commences (1 hour minimum).

All direct burial splices shall be in a manhole or a hand hole. With the exception of stake mounted lights per Specification L-125, splicing of buried cables directly in the soil is not permitted.

108–3.2 INSTALLATION IN DUCT OR CONDUIT. This Work includes the installation of the cable in duct or conduit as described herein. 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 in accordance with the latest edition of NFPA 70.

Install the duct or conduit as a separate Pay Item in accordance with Specification L–110, "Installation of Airport Underground Electrical Duct." Make sure that the duct is open, continuous, and clear of debris before installing cable. Install the cable in a manner to prevent harmful stretching of the conductor, injury to the insulation, or damage to the outer protective covering. Seal the ends of all cables with moisture–seal tape before pulling into the conduit and left seal it until connections are made. Where more than one cable is to be installed in a duct under the same Contract, pull all cable in the duct at the same time. Pull cable through ducts or conduits by hand winch or power winch with the use of cable grips or pulling eyes. Pulling tensions should be governed by recommended standard practices for straight pulls or bends. Where pulling lubricant is required use a lubricant recommended for the type of cable being installed. Replace duct or conduit markers temporarily removed for excavations and include the cost in the price for cable installation.

108–3.3 TRENCHING. Where turf is well established and the sod can be removed, carefully strip and properly store it. Trenches for cables may be excavated manually or with mechanical trenching equipment. Walls of trenches shall be essentially vertical so that a minimum of shoulder surface is disturbed. Do not use road graders to excavate the trench with their blades. The bottom surface of trenches shall be essentially smooth and free from coarse aggregate. Unless otherwise specified, excavate cable trenches to a depth as indicated in the Contract Documents.

Excavate all cable trenches to a width as indicated in the Contract Documents. Widen the trench where more than two cables are to be installed parallel in the same trench as shown in the Contract Documents. Unless otherwise specified in the Contract Documents, install all cables in the same location and running in the same general direction in the same trench.

When rock excavation is encountered, remove the rock to a depth of at least 3 inches (75 mm) below the required cable depth and replace it with bedding material of earth or sand containing no mineral aggregate particles that would be retained on a 1/4–inch (6 mm) sieve. Ascertain the type of soil or rock to be excavated before bidding. Excavation shall be incidental to this Pay Item.

108–3.4 INSTALLATION IN TRENCHES. Mechanical cable–laying equipment may be used in conjunction with a trenching machine if indicated in the Contract Documents; and it should provide for physical inspection of cable prior to backfilling. Sharp bends or kinks in the cable are not permitted.

Unreel cables in place alongside or in the trench and carefully place the cable along the bottom of the trench. Do not unreel the cable and pull into the trench from one end.

Whenever cables (including counterpoise) cross, adjust the trench depth to provide 3" vertical clearance between 5KV conductors; 6" vertical clearance between 600V conductors and 5KV conductors; and 4" vertical clearance between any conductor and the counterpoise conductor. Counterpoise shall always maintain an 8" vertical depth at the edge of pavement and 18" vertical depth when the counterpoise is located above home run circuits. All other cables shall meet NFPA section 70 requirements.

Leave cable slack on each side of all connections, insulating transformers, light units, and at all other points where cable is connected to field equipment. Place the slack cable in the trench in a series of S curves. Leave additional slack cable in runway light bases, handholes, manholes, and other locations where it is required to bring the cable above ground level to make connections. The amount of slack cable shall be as shown in the Contract Documents. Slack cable for above ground connections will be paid as defined in Method of Measurement.

108–3.5 BACKFILLING. After the cable or conductors have been installed on a 3" sand bedding, the first layer of backfill shall be loose measurement, and shall be sand containing no mineral aggregate particles that would be retained on a 1/4–inch (6 mm) sieve. Do not compact this sand backfill layer. The second and subsequent layers shall be as shown on the Drawings and shall contain no particles larger than 1 inch (25 mm) maximum diameter. The top layer of the backfill shall be topsoil. Do not place material in a manner that would stress or damage the cable.

Thoroughly tamp and compact the second, and subsequent layers to at least the density of the adjacent undisturbed soil, and to the satisfaction of the Engineer. If necessary to obtain the desired compaction, moisten or aerate the backfill material as required.

Trenches shall not be excessively wet and shall not contain pools of water during backfilling operations. Completely backfill the trench and tamp it level with the adjacent surface, except that when sod is to be placed over the trench, stomp the second backfilling at a depth equal to the thickness of the sod to be used, with proper allowance for settlement. Remove excess excavated material and dispose of it in accordance with the Contract Documents. All backfilling shall be incidental and the cost included in the Pay Items contained in the Schedule of Prices

Trenches for polyethylene duct will not require sand bedding or a first layer of sand backfill. However, the second and subsequent layers and top layer of topsoil shall comply with paragraph 108–3.5.

108–3.6 RESTORATION. Restore pavement and other surface features disturbed by trenching, plowing, cable installation, storage of materials, and other Contractor operations, to a condition equal to or exceeding that which existed prior to construction. Restore turf as follows:

a. When grading limits are shown on the Plans and the Schedule of Prices contains Pay Items for Salvaged Topsoil, Seeding, Fertilizing, and Mulching, restore the area within the grading limits in accordance with requirements shown on the Plans and contained in the turfing Specifications for areas disturbed by grading operations.

b. Complete turf restoration, for turf disturbed by trenching, plowing, and cable installation outside grading limits, or when there are no grading limits shown, by removing and replacing existing sod or by replacing the disturbed turf with topsoil or salvaged topsoil, seeding, and mulching, in accordance with Specification T–901, T–902, T–905, and T–908. The finished surface upon completion of restoration shall be graded smooth and uniform to match existing slope, and shall be free from ruts over 1 inch in depth and stones over 1 inch in diameter. Maintain and water the turf. Replace seeded areas that do not "catch."

NOTE TO SPECIFIER:
Grading limits should be shown on the Plans for Contracts that include earthwork.

108–3.7 CABLE AND SPLICE MARKERS. Define the location of runway light circuits and splices with concrete markers. In general, mark home run circuits from the runway lights approximately every 200 feet (60 m) along the cable run, with an additional marker at each change of direction of cable run. Mark all other cable buried directly in the earth in the same manner. Do not install markers where cable lies in straight lines between pavement edge lights or obstruction light poles which are spaced 300 feet (90 m) apart, or less. Install markers immediately above the cable or splice. Impress the legend and directional arrows on each marking slab as required by the Contract Documents. The letters shall be approximately 4 inches (100 mm) high and 3 inches (75 mm) wide, with width of stroke 1/2 inch (12 mm) and 1/4 inch (6 mm) deep. Legends inscribed by hand in wet concrete are not acceptable. Edge expose concrete with a 1/4 inch radius tool.

108–3.8 PLOWING. Plowing equipment shall be of the vibratory type.

The plow blade shall be of sufficient length to facilitate installation of the cable conductors or non–metallic conduit at the specified depth. Size the shoe throat for the cable size and the number of cable conductors or non–metallic conduit specified. Cable ways and guides shall be smooth, free of obstructions and sharp edges, and shall not cause bending of the cable conductors or non–metallic conduit at shorter than 6

times their radius. It also shall not cause excessive cable strain which may damage cable insulation or stretch the conductor. Maintain adequate cable on the reel to avoid splices.

For ground rods, dig a hole along the cable route at each ground rod location. The diameter of this hole shall be as necessary and the depth shall be 10 inches deeper than the cable. There shall be a measure of slack at each ground rod to perform the connection process and accommodate movement caused by frost heaving.

At the light hole and duct hole, stop the plow (movement and vibration), raise it and hand pull the required amount of slack. Take care during this operation that the cable at the entrance into the light hole is not pulled from the specified depth. Continue plowing by lowering the plow, starting it and holding the cable by hand before it is firmly held by the ground.

The cable may be unreeled along the proposed cable route before plowing or the cable reels may be mounted on the tractor. In the latter case, unreeling of the cable shall not cause excessive tension in the cable.

After the tractor and the plow are positioned at the beginning of the run, sufficient cable conductor or non–metallic conduit slack shall be pulled through the throats. Then lower the plow into the hole and hand hold the cable for the start of plowing.

Do not back the plow onto the cable or conductors.

When an underground obstruction is encountered, lift the plow out of the ground. After the obstruction has been removed, dig an opening around the cable down to the depth of the cable and large enough to lower the plow. Then lower the plow into the opening. While this is being done, pull the cable back into the throat by hand to prevent kinks or sharp bends. Do not bend cable sharper than six times the radius of the cable, conductor, or non–metallic conduit.

After installation by plowing, level the disturbed earth at the surface and if necessary, compact it to the density of the adjacent undisturbed earth.

Mark the location of each underground cable splice in a handhole by a marker placed above the handhole. Impress the word "splice" on each slab.

108–3.9 CONNECTIONS. In line connections of the type shown in the Contract Documents shall be made by experienced personnel regularly engaged in this type of work and shall be made as follows:

a. Cast Splices. Use crimp connectors for jointing conductors. Assemble molds and mix and pour the compound in accordance with manufacturer's instructions and to the satisfaction of the Engineer.

b. Vulcanized Splices. Use crimp connectors for joining conductors. Make the splice using compounds furnished by the manufacturer, in accordance with the manufacturers instructions and to the satisfaction of the Engineer.

c. Field–attached Plug–in Connectors. Assemble these in accordance with manufacturer's instructions. Make these splices by plugging directly into mating connectors. In all cases seal the joint where the connectors come together with heat shrink tubing as required by the Contract Documents and these Specifications.

d. Factory–Molded Plug–in Connections. Make these by plugging directly into mating connectors. In all cases, wrap the joint where the connectors come together 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 (37 mm) on each side of the joint.

e. Taped Connections. Make a taped splice in the following manner:

Bring the cables to their final position and cut so that the conductors will butt. Remove insulation and jacket allowing for bare conductor of proper length to fit compression sleeve connector with 1/4 inch (6 mm) of bare conductor on each side of the connector. Use a sharp knife to pencil insulation and jacket at approximately the same angle as a pencil point. Care must be taken to avoid nicking or injuring the conductor during removal of insulation or penciling. Do not use emery paper on splicing operations since it contains metallic particles. Thoroughly clean the copper conductors. Join the conductors by inserting them equidistant into the compression connection sleeve. Crimp conductors firmly in place with a crimping tool that requires a complete crimp before the tool can be removed. Test the crimped connection by pulling on the cable. Scrape the insulation to assure that the entire surface over which the tape will be applied (plus 3 inches (75 mm) on each end) is clean. After scraping, wipe the entire area with a clean lint–free cloth. Do not use solvents.

Apply specified high–voltage rubber tape one–half lapped over bare conductor. This tape should be tensioned as recommended by the manufacturer. Voids in the connector area may be eliminated by highly elongating the tape stretching it just short of its breaking point. Throughout the rest of the splice less tension should be used. Always attempt to exactly half–lap to produce a uniform buildup. Continue buildup to 1–1/2 times cable diameter over the body of the splice with ends tapered a distance of approximately 1 inch (25 mm) over the original jacket. Cover rubber tape with two layers of specified vinyl pressure–sensitive tape one–half lapped. Do not use glyptol or lacquer over vinyl tape as they react as solvents to the tape. No further cable covering or splice boxes are required.

If shielded cable is to be spliced, prepare cable as for a regular taped splice, except remove the neoprene jacket a distance not less than 5 inches (125 mm) from the beginning of the penciled portion. Carefully unwrap the shielding tape from that portion where jacket has been removed and cut off so that it extends about 1 inch (25 mm) from end of the jacket. Proceed with the taped splice as described above and tape up to 1/4 inch (6 mm) from the shield on both ends. Build up rubber tape to a thickness equal to the insulation thickness or 5/16 inch (9 mm) over connector.

Next wrap one–half lapped layer of semi–conducting tape (Scotch No. 13 Semi–Conducting Tape, or equal) over splicing tape and 1/4 inch (6 mm) onto the shielding tape. Wrap a fine, flat shielding braid one–half lapped over the splice extending 1/2 inch (12 mm) onto the metallic shielding. Solder ends of braid to metallic shielding tape. A bonding wire, (Minimum No. 14 Stranded Copper) equal to the current carrying capacity of the metallic shield, should have the individual strands wrapped around the metallic shield at both ends of the splice. These strands should be tack soldered to the shield in several places. The cable sheath should be replaced by wrapping with two one–half lapped layers of vinyl tape extending 2 inches (50 mm) onto the cable jacket.

The above described splice is for a straight–through splice with continuity of shielding.

f. Heat Shrink Connections. Make these with a heat shrinkable insulating cover, specifically designed for splices and terminations per UL 486D. The head shrink material shall be made of thermally stabilized cross linked polyolefin, rated 90°C, designed with a 3:1 shrink ratio. The material shall have a factory internally applied adhesive sealant, which is applicable to metal, plastic and elastomeric insulating materials.

Heat shrink application and installation procedures, shall conform to the manufacturers instructions.

g. Connection Rating. The dielectric strength and insulation rating of all connection materials, application and installation methods, shall be equal to or exceed the rating of the cables or conductors spliced together.

108–3.10 BARE COUNTERPOISE WIRE INSTALLATION AND GROUNDING FOR LIGHTNING PROTECTION. When shown in the Contract Documents, install a stranded or solid bare copper wire, No. 8 AWG minimum size, for lightning protection of the underground cables. Install the bare counterpoise wire as required in the Contract Documents. Install homerun circuits in the same trench for the entire length of the insulated cables it is designed to protect. Securely attach the counterpoise wire to copper or copper–clad ground rods installed not more than 500 feet (150 m) apart for the entire circuit and at the beginning and end of each counterpoise circuit. The ground rods shall be of the length and diameter specified in the Contract Documents, but never less than 8–feet (2.4 m) long nor less than 5/8 inch (15 mm) in diameter.

Terminate the counterpoise system outside structures that enclose the power source for the circuit protected. Make the connections as shown in the Contract Documents.

108–3.11 TEST, LOCATE AND PROTECT EXISTING CIRCUITS. Work includes the testing and location of all power and control circuits that are located within the construction area or haul routes: providing temporary connection/cable runs to enable operation as required by construction staging of airport lighting systems during darkness, weekends, holidays and instrument conditions; prompt repair or replacement of electrical cables or equipment damaged during construction operations; careful handling of any FAA installed cables or equipment encountered during construction; and removal/reinstallation of existing cables.

Immediately prior to construction, obtain meggar test readings of all airport circuits that will be encountered during construction, including those crossed by haul routes or access roads, shall be taken in the presence of the Sponsor and the Engineer. If the Contractor notes problems in the existing circuits prior to starting Work, these circuits may be repaired by the Sponsor or noted to the mutual satisfaction of the Contractor and the Sponsor as not being the responsibility of the Contractor. Test circuits repaired by the Sponsor once again prior to construction.

Upon completion of construction, in the presence of the Sponsor and the Engineer, Meggar test all airport circuits encountered during construction. Repair all portions of circuits that have been damaged during construction.

The excavation, cutting, pulling–out and reinstallation of existing cables as required in the Contract Documents shall be incidental to this Pay Item. Provide temporary above–ground connections in protective conduit, as shown on Contract Documents or as conditions and environment warrant. All temporary connections shall use L–823 cable connectors, taped and waterproofed as shown on the Contract Documents. The Contractor's superintendent or on–site representative must remain in communication with the Engineer until such repairs are completed and the lighting system has been checked for operation and accepted by the Sponsor.

108–3.12 FINAL ACCEPTANCE AND TEST. Furnish all necessary equipment and appliances per Specification 100–2.13 for testing the underground cable circuits after installation. Test and demonstrate the following:

a. That all lighting power and control circuits are continuous and free from short circuits.

b. That all circuits are free from unspecified grounds.

c. That the insulation resistance to ground of all ungrounded constant current circuits meets the requirements of Table 1.

d. That the insulation resistance to ground of all ungrounded constant voltage circuits meets the requirements of Specification 100–3.3(h).

TABLE 1. INSULATION RESISTANCE TO GROUND

CIRCUIT LENGTH IN FEET	*MINIMUM MEGOHMS AT 500VDC*	*MINIMUM MEGOHMS AT 1000VDC*
10,000 OR LESS	50	45
10,000 – 20,000	40	36
20,000 OR MORE	30	27

e. That all circuits are properly connected in accordance with applicable wiring diagrams.

f. That all circuits are operable. Tests shall be conducted that include operating each control not less than 10 times and the continuous operation of each lighting and power circuit for not less than 1/2 hour.

g. Test shall be conducted per Subsection 100-2.12.

METHOD OF MEASUREMENT

108–4.1 LOCATE AND PROTECT EXISTING CIRCUITS. Locate and Protect Existing Circuits will be measured for payment as a complete unit per lump sum.

NOTE TO SPECIFIER:
It is intended that when the Pay Item Cable Plow is included in the Schedule of Prices, Cable Trench will also be bid. If the Pay Item Cable Trench or Plow is bid, the Pay Items Cable Plow and Cable Trench should not be used unless a Special Provision or Plan note is included to specify where measurement will be made.

108–4.2 PLOW. Plow will be measured for payment on a unit price basis per linear foot. Measurement will be made in straight horizontal lies between lights, signs, and angle points shown on the Plans.

108–4.3 TRENCH. Trench of the various sizes indicated will be measured for payment on a unit price basis per linear foot. Measurement will be made in straight horizontal lines along the centerline of trench constructed and accepted for payment. Trench will only be measured for payment when Trenches of the various sizes required are designated on the Drawings and corresponding Pay Items are included in the Schedule of Prices; otherwise, all cable trenches and length of plowing will be measured as Trench or Plow. If the Pay Item for Trench or Plow and the Pay Item for various sizes of trench are included in the Contract Documents, only portions of trench specifically designated on the Plan to be measured for payment as Trench will be measured as such; otherwise, trench will be included in the measurement for Trench or Plow.

108–4.4 TRENCH OR PLOW. Trench or Plow will be measured for payment on a unit price basis per linear foot. Measurement will be made along the centerline of the various sizes of trench and lengths of plowed cables. Measurement will be made in straight horizontal lines between lights, signs, and angle points shown on the Plans. Trench of various sizes will not be measured separately for payment when this Pay Item is included in the Schedule of Prices. The depth of trench and plowing will be incidental.

108-4.5 COUNTERPOISE TRENCH OR PLOW. Counterpoise Trench or Plow will be measured for payment on a unit price basis per linear foot. Measurement will be made along the centerline of the trench and lengths of plowed counterpoise. Measurement will be made in straight horizontal lines between angle points shown on the Plans. The depth of trench and plowing will be incidental.

108–4.6 CABLE. Cable of the various sizes and types indicated will be measured on a unit price basis per linear foot of cable, furnished, installed and accepted. Measurement for payment will be determined based upon the straight line measurement of the associated duct, trench, or plow lengths, multiplied by the numbers of cables installed in each length. The 3 feet of cable length required for each isolation transformers, will be added to the length measured for payment.

108-4.7 FLEXIBLE POLYETHYLENE DUCT. Flexible Polyethylene Duct will be measured on a unit price basis per linear foot of duct, furnished, installed and accepted. Measurement for payment will be determined based upon the straight line measurement along the centerline of the duct installed.

108-4.8 COUNTERPOISE. Counterpoise of the various sizes indicated will be measured on a unit price basis per linear foot of counterpoise, furnished, installed and accepted. Measurement for payment will be determined based upon the straight line measurement of the associated trench or plow lengths.

108–4.9 COUNTERPOISE GROUND RODS. Counterpoise Ground Rods will be measured for payment on a unit price basis for each.

108–4.10 CABLE AND SPLICE MARKERS. Cable and Splice Markers will be measured for payment on a unit price basis per each. Splice markers will be measured as Cable Markers.

108-4.11 TURF RESTORATION. Turf Restoration will be measured for payment on a unit price basis per linear foot. Measurement will be made in a straight horizontal line, between angle points along trenches or plowed cable, outside of the grading limits shown on the Plans.

NOTE TO SPECIFIER:
Grading limits must be shown on drawings for projects with excavation and embankment.

BASIS OF PAYMENT

108–5.1 LOCATE AND PROTECT EXISTING CIRCUITS. Payment will be made at the Contract Lump Sum price for Locate and Protect Existing Circuits and will be full compensation for furnishing all materials for locating, protecting, and testing existing circuits and for all labor, equipment, tools, and incidentals necessary to complete this Pay Item as required in the Contract Documents.

108–5.2 PLOW. Payment will be made at the Contract unit price per linear foot for Plow. This Pay Item will include plowing operations for the installation of the various sizes and types of cable, and flexible polyethylene duct required in the Contract Documents. Amounts paid for this Pay Item will be full compensation for furnishing all materials required for a complete installation and not specifically paid for under other Pay Items, repair of cable damaged by construction operations, preparation for the installation of these materials, and the plowing operation; including all labor, equipment, tools, and incidentals necessary to compete the Work.

108–5.3 TRENCH. Payment will be made at the Contract unit price per linear foot for the various sizes of Trench. These Pay Items will include construction of trenches for the installation of the various sizes and types of conductor cable, and flexible polyethylene duct required in the Contract Documents. Amounts paid for these Pay Items will be full compensation for furnishing all materials required for a complete installation and not specifically paid for under other Pay Items, repair of cable damaged by construction operations, preparation for the installation of these trench construction and backfill and plowing operations, including all labor, equipment, tools, and incidentals necessary to complete the Work.

108–5.4TRENCH OR PLOW. Payment will be made at the Contract unit price per linear foot for Trench or Plow. This Pay Item will include construction of the various sizes of trench or plowing operations for the installation of the various sizes and types of cable and flexible polyethylene duct required in the Contract Documents. Amounts paid will be full compensation for furnishing all materials required for a complete installation and not specifically paid for under other Pay Items, repair of cable damaged by construction operations, and preparation for the installation of these trench construction and backfill and plowing operations; including all labor, equipment, tools, and incidentals necessary to complete the Work.

108-5.5 COUNTERPOISE TRENCH OR PLOW. Payment will be made at the Contract unit price per linear foot for Counterpoise Trench or Plow. This Pay Item will include construction of the trench or plowing operations for the installation of the various sizes of counterpoise required in the Contract Documents. Amounts paid will be full compensation for furnishing all materials required for a complete installation and not specifically paid for under other Pay Items, repair of cable damaged by construction operations, preparation for the installation of materials, and trench construction and backfill and plowing operations; including all labor, equipment, tools, and incidentals necessary to complete the Work.

108–5.6 CABLE. Payment will be made at the Contract unit price per linear foot for the various sizes and types of cable and connections furnished and installed in duct, trench, or plow in accordance with the Contract Documents. These prices will be full compensation for furnishing all materials and for delivery, preparation, and installation of these materials, including all labor, equipment, tools, testing, and incidentals necessary to complete the Work;, except the cost of flexible polyethylene duct (on projects where flexible polyethylene duct is required), and trenching, plowing, or trench and plow, which will be included in separate Pay Items.

108-5.7 FLEXIBLE POLYETHYLENE DUCT. Payment will be made at the Contract unit price per linear foot for Flexible Polyethylene Duct furnished and installed in accordance with the Contract Documents. These prices will be full compensation for furnishing all materials

and for delivery, preparation, and installation of these materials, including all labor, equipment, tools, testing, and incidentals necessary to complete the Work, except the cost of trenching, plowing, or trench and plow, which will be included in separate Pay Items.

108-5.8 COUNTERPOISE. Payment will be made at the Contract unit price per linear foot for the various sizes of counterpoise furnished and installed in accordance with the Contract Documents. These prices will be full compensation for furnishing all materials and for delivery, preparation, and installation of materials, including all labor, equipment, tools, testing, and incidentals necessary to complete the Work, except the cost of trenching, plowing, or trench and plow, which will be included in a separate Pay Item.

NOTE TO SPECIFIER:
The cost for trenching or plow for cable and counterpoise shall be included in Pay Items separate from the Pay Items for cable and counterpoise.

108–5.9 COUNTERPOISE GROUND RODS. Payments will be made at the Contract unit price per each for Counterpoise Ground Rods constructed and accepted. This price will be full compensation for furnishing materials and for preparation and installation, including labor, equipment, tools, and incidentals necessary to complete the Work.

108–5.10 CABLE AND SPLICE MARKERS. Payment will be made at the Contract unit price per each for Cable Markers constructed and accepted. This price will be full compensation for furnishing materials and for preparation and installation, including labor, equipment, tools, and incidentals necessary to complete the Work. Splice markers will be paid as cable markers.

108–5.11 TURF RESTORATION. Payment for restoration of pavement and other surface features disturbed by trenching, plowing, cable laying, storage of materials, and other Contractor operations required for installation of cable, conductors, and appurtenant Work, shall be incidental and the cost included in the prices for Trench or Trench or Plow. Basis of Payment for turf restoration shall be as follows:

a. When the Contract contains grading for Airport Improvements and includes Pay Items for Topsoil or Salvaged Topsoil, Seeding, Fertilizing, and Mulching, turfing shall be completed, measured, and paid as required in Specifications T–901, T–902, T–905, and T–908 within the grading limits shown on the Plans. The Items for Topsoiling or Salvaged Topsoil, Seeding, Fertilizing, and Mulching will only be measured and paid once for work areas within the grading limits. Coordination of the construction operations for the various parts of the Work to maintain the schedule and to complete grading, electrical, and turfing in accordance with the Contract Documents shall be incidental to the other items of the contract and no separate or additional compensation will be made.

b. When cable or conductors are installed outside grading limits, turf restoration shall be completed by removing and replacing existing sod or by restoring the turf with topsoil or salvaged topsoil, fertilizer, seeding and mulching in accordance with Specifications T–901, T–902, T–905, and T–908. Measurement will be made as specified herein, and payment will be made at the Contract unit price per linear foot. This price will include furnishing all materials for grading, topsoiling, seeding, mulching, and maintenance, replacement of areas that did not "catch", and for preparation and installation including all labor, equipment, tools, and incidentals necessary to complete the Work.

c. When there are no Pay Items for turf restoration contained in the Schedule of Prices, turf restoration will be incidental and the cost included in Pay Items for Trench, or Trench or Plow.

108-5.12 Standard Pay Items for Work covered by this Specification are as follows:

Pay Item L10801	Locate and Protect Existing Circuits, per lump sum
Pay Item L10802	Plow, per lineal foot
Pay Item L10803	Trench 6", per linear foot
Pay Item L10804	Trench 9", per linear foot
Pay Item L10805	Trench 12", per linear foot
Pay Item L10806	Trench 18", per linear foot
Pay Item L10807	Trench 21", per linear foot
Pay Item L10808	Trench 24", per linear foot
Pay Item L10809	Flexible Polyethylene Duct, per lineal foot
Pay Item L10810	Trench or Plow, per lineal foot
Pay Item L10811	Counterpoise Plow, per lineal foot
Pay Item L10812	5000 Volt Cable No. 8, per lineal foot
Pay Item L10813	600 Volt Cable, No. 4, per lineal foot
Pay Item L10814	600 Volt Cable, No. 6, per lineal foot
Pay Item L10815	600 Volt Cable, No. 8, per lineal foot
Pay Item L10816	600 Volt Cable, No. 10, per lineal foot
Pay Item L10817	Bare Counterpoise Wire, No. 6, per lineal foot
Pay Item L10818	Bare Counterpoise Wire, No. 8, per lineal foot
Pay Item L10819	Counterpoise Ground Rod, per each
Pay Item L10820	Cable Markers, per each
Pay Item L10821	Turf Restoration, per lineal foot

MATERIAL REFERENCES

Measurement and Payment will only be made for Pay Items included in the Schedule of Prices. The cost of all Work required by the Contract Documents will be included in the Pay Items contained in the Schedule of Prices.

AC 150/5345-7	Specification for L-824 Underground Electrical Cable for Airport Lighting Circuit
AC 150/5345-26	Specification for L-823 Plug and Receptacle Cable Connectors

SPECIFICATION L–109. INSTALLATION OF VAULT ELECTRICAL EQUIPMENT

DESCRIPTION

109–1.1 GENERAL.

a. This Work consists of the furnishing and installation of equipment in a vault or prefabricated metal housing in accordance with these Specifications and with the design and dimensions shown in the Contract Documents. The Work includes enclosure facilities equipment; the painting of equipment; the marking and labeling of equipment and the labeling or tagging of wires; the testing of the installations; and the furnishing of all incidentals necessary to place it in operating condition as a completed unit.

109-1.2 THIS SPECIFICATION INCLUDES:

a. Regulatory Requirements.
b. Regulators.
c. Regulator Monitors.
d. L-847 Circuit Switch Selector.
e. L-841 Relay Cabinets per.
f. L-854 Radio Controller
g. Generators per FAA

109-1.3 OTHER RELATED SPECIFICATIONS.

a. L-100-1.1 through L-100-2.17 General Requirements.
b. L-100-3.2 Raceways.
c. L-100-3.3 Feeder and Branch Circuit Wire and Cable.
d. L-100-3.4 Control and Signal Wire and Cable.
e. L-100-3.5 Electrical Boxes and Fittings.
f. L-100-3.6 Wiring Devices.
g. L-100-3.7 Cabinets and Enclosures.
h. L-100-3.8 Supporting Devices.
i. L-100-3.9 Electrical Identification.
j. L-100-3.10 Secondary Grounding.
k. L-100-3.11 Panelboards.
l. L-100-3.12 Overcurrent Devices.

109-1.4 CLASSIFICATIONS.
Not used.

EQUIPMENT AND MATERIALS

109–2.1 REGULATORY REQUIREMENTS.

a. Airport lighting equipment and materials requiring Federal Aviation Administration (FAA) specifications shall have the prior approval of the FAA, and be listed in the latest edition of Advisory Circular (AC) 150/5345–53, Appendix 3.

b. All other electrical equipment and materials shall be subject to acceptance through manufacturer's certification of compliance as required in Specification L–100.

109-2.2 REGULATOR. The regulator shall meet the requirements of the latest edition of AC 150/5345-10.

109-2.3 REGULATOR MONITOR. The regulator monitor shall meet the requirements of the latest edition of AC 150/5345-10.

109-2.4 L847 CIRCUIT SELECTOR SWITCH. The l847 circuit selector switch shall meet the latest edition of AC 150/5345-5.

109-2.5 L841 RELAY CABINET. The L841 relay cabinet shall meet the latest edition of AC 150/5345-13.

109-2.6 L854 RADIO CONTROLLER. The L854 radio controller shall meet the latest edition of AC 150/5345-49.

109-2.7 GENERATOR. The generator shall meet the latest edition of FAA specification E-2204.

NOTE TO SPECIFIER:
If particular materials are required, they should be specified by Special Provision or Plan notes.

It is suggested that only metal conduit be used without concrete encasement, as a matter of cost. Metal conduit by itself will withstand the compacted strength to withstand subbase preparation for runway pavement.

NOTE TO SPECIFIER:
Pushing of duct under paved areas, and hydraulic boring of holes for pushing conduit, are not part of the standard specifications. Although the practice is well recognized and accepted, it is not without faults, specifically under runways, taxiways, and aprons. As a result, this work will remain at the discretion of the Engineer and will require Special Provisions.

CONSTRUCTION METHODS

109–3.10 GENERAL. Furnish, install, and connect all equipment, electrical facilities equipment, accessories, conduit, cables, wires, buses, grounds, and support necessary to insure a complete and operable electrical distribution center for the airport lighting system as specified herein and shown in the Contract Documents. When specified, provide and install an emergency power supply and transfer switch.

109–3.11 SEPARATELY DERIVED POWER EQUIPMENT. Furnish and install transformers, regulators, booster transformers, and other power supply equipment items at the location shown in the Contract Documents. Set the equipment to provide space for maintenance and code clearance. Place the equipment so as not to obstruct the oil–sampling plugs of the oil–filled units; and name–plates shall, so far as possible, not be obscured.

If specified, furnish and install the equipment for an emergency power generator. The installation shall include all equipment, accessories, an automatic transfer switch, and all necessary wiring and connections. The emergency power generator set shall be the size and type specified.

109–3.12 DISTRIBUTION EQUIPMENT. Furnish and install switches, cutouts, relays, transfer switches, panels, panel boards, and other similar items at the location shown in the Contract Documents. Attach wall or ceiling–mounted items to the wall or ceiling with galvanized bolts engaging metal expansion shields or anchors in masonry or concrete.

109–3.13 CABLE ENTRANCE. Incoming underground cable from field circuits installed from outside of the vault or premanufactured metal housing will be measured as a separate Pay Item under Specification L–108. Bring the cables from the trench or duct through the entrance conduits into the enclosure and make the necessary electrical connections under Specification L–108. Furnish and install the incoming public utility circuits under this Specification.

109–3.14 WIRING AND CONNECTIONS. Make all necessary electrical connections in accordance with the Contract Documents. In wiring to the terminal blocks, leave sufficient extra length on each control lead to make future changes in connections at the terminal block. Accomplish this by running each control lead the longest way around the box to the proper terminal. Leads shall be neatly laced in place.

METHOD OF MEASUREMENT

109–4.1 Equipment, Installed in vault or enclosure will be measured and paid as a complete unit per lump sum,

109–4.2 The quantity for regulators, monitors, circuit switch selectors, L-841 relay cabinets, L-854 radio controllers, and generators to be measured and paid will consist of the number and type in place as a complete unit per each.

109-4.3 Electric utility service will be measured as complete units per lump sum at location indications in the contract document.

BASIS OF PAYMENT

109–5.1 Payment will be made at the Contract unit price for each completed and accepted installation. This price will be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the Work.

a. Payment for Equipment, Installed in a vault or prefabricated metal housing will be made at the Contract lump sum price for each completed and accepted installation. This price will be full compensation for furnishing all enclosure facilities equipment, including, but not limited to, raceways, wiring, controls, boxes, fittings, wiring devices, cabinets, enclosures, electrical identification, interior and exterior lighting, distribution systems, separately derived power sources, switches, and heating and ventilating equipment, all as specified in the Contract Documents.

b. Payment for regulators, regulator monitors, L-847 circuit switch selectors, L-841 relay cabinet, and L-854 radio controller and generator will be made at the contract unit price for each completed unit. This price will be full compensation for each unit installed in place, including all provisions, attachments. connectors, accessories, tools, labor, and incidentals necessary to complete the work, installed, tested, and accepted.

c. Electric Utility Service shall include providing an electric service from the electric utility, including coordination, costs, fees, and all appurtenant Work.

NOTE TO SPECIFIER:
Obstruction lighting is bid per lump sum for discrete locations. The plans should show the location and define the lights and appurtenances to be included in each location. Single lights or multiple lights may be included in a location. If Electric Utility service is required, it is also bid per location. Power sources from existing airport facilities are incidental, except for cable paid under L–108. The limits of cable to be measured should be indicated on the Plans.

Standard Pay Items for Work covered by this Specification are as follows:

Pay Item L10901 through L10905	Equipment, Installed, Location No. ___, per lump sum
Pay Item L10906 through L10910	Electrical Utility Service, Location No. ___ per lump sum
Pay Item L10901	Regulator, 6.6A, 4KW, per each
Pay Item L10902	Regulator, 6.6A, 7–1/2KW, per each
Pay Item L10903	Regulator, 6.6A, 10KW, per each
Pay Item L10904	Regulator, 6.6A, 15KW, per each
Pay Item L10915	Regulator, 6.6A, 20KW, per each
Pay Item L10916	Regulator, 6.6A, 30KW, per each
Pay Item L10917	Regulator Monitor, per each
Pay Item L10918	L-847 Circuit Switch Selector, per each
Pay Item L10919	L-841 Relay Cabinet, per each
Pay Item L10920	L-854, Radio Controller, per each
Pay Item L10921	Generator, per each

Measurement and Payment will only be made for Pay Items included in the Schedule of Prices. The cost of all Work required by the Contract Documents will be included in the Pay Items contained in the Schedule of Prices.

MATERIAL REQUIREMENTS

AC 150/5345-5	Specification for Circuit Switch Selector
AC 150/5345-10	Specification for Constant Current Regulators and Regulator Monitors
AC 150/5345-13	Specification for L-841 Relay Cabinet
AC 150/5345-49	Specification for L-854 Radio Controllers
FAA E2204	Specification for Generators

SPECIFICATION L–110. INSTALLATION OF AIRPORT UNDERGROUND ELECTRICAL DUCT

DESCRIPTION

110–1.1 GENERAL.

a. This Work consists of underground electrical ducts and underground conduits installed in accordance with this Specification at the locations and in accordance with the dimensions, designs, and details shown in the Contract Documents. Also include all excavation, trenching, backfilling, removal, and restoration of paved areas, manholes, concrete encasement, mandreling, installation of steel drag wires and duct markers, capping, and the inspection of the installation as a completed duct system ready for installation of cables, unless otherwise shown in the Contract Documents.

110-1.2 THIS SPECIFICATION INCLUDES:

a. Regulatory Requirements.

110-1.3 OTHER RELATED SPECIFICATIONS.

a. L100-1.1 through L-100-2.17 General Requirements.
b. L-100-3.2 Raceways.

110-1.4 CLASSIFICATIONS.

a. Type I - Duct encased in concrete.
b. Type II - Duct without concrete encasement.

EQUIPMENT AND MATERIALS

110–2.1 REGULATORY REQUIREMENTS. All equipment and materials shall be subject to acceptance through manufacturer's certification of compliance with applicable specifications and as required in Specification L-100.

CONSTRUCTION METHODS

110–3.1 GENERAL. Install underground ducts at the approximate locations shown in the Contract Documents. The Engineer will indicate specific locations as the work progresses. Ducts shall be of the size, material, and type indicated in the Contract Documents. Where no size is indicated in the plans or specifications the ducts shall be not less than 3 inches (75 mm) inside diameter. Lay all duct lines to drain toward handholes, manholes and duct ends. Grades shall be at least 3 inches (75 mm) per 100 feet (30 m). On runs where it is not practicable to maintain the grade all one way, grade the duct lines from the center in both directions toward manholes, handholes, or duct ends. Avoid pockets or traps where moisture may accumulate.

Mandrel each duct. Push An iron–shod mandrel, not more than 1/4–inch (6 mm) smaller than the bore of the duct through each duct by means of jointed conduit rods. The mandrel shall have a leather or rubber gasket slightly larger than the duct hole.

All ducts installed shall be provided with a No. 10 gauge galvanized iron or steel drag wire for pulling the permanent wiring. Where steel spare ducts are installed, as indicated on the plans, plug the open ends with removable tapered plugs, designed by the duct manufacturers, or with hardwood plugs conforming accurately to the shape of the duct and having the larger end of the plug at least 1/4–inch (6 mm) greater in diameter than the duct. Use plugs recommended by the manufacturer for plastic and fiber duct. Securely fasten and plug all ducts in place during construction and progress of the work to prevent seepage of grout, water, or dirt. Do not install duct sections having a defective joint.

Install ducts under runways, taxiways, aprons, and other paved areas in accordance with details shown on the Drawings. When required, provide concrete encasement as shown on Drawings.

Excavate the trenches for ducts manually or with mechanical trenching equipment. Walls of trenches shall be vertical so that a minimum of shoulder surface is disturbed. Do not use blades of road graders to excavate the trench. Ascertain the type of soil or rock to be excavated before bidding. All excavation shall be unclassified and incidental to this Item.

110–3.2 DUCTS ENCASED IN CONCRETE (TYPE I). When shown in the Plans, install concrete–encased ducts so that the top of the concrete envelope is not less than 18 inches (450 mm) below the finished subgrade where installed under runways, taxiways, aprons, or other paved areas, and not less than 18 inches (450 mm) below finished grade where installed in unpaved areas. Extend ducts under paved areas at

least 5 feet (1.5 m) beyond the edges of the pavement or 5 feet (1.5 m) beyond underdrains that may be installed alongside the paved area. Open trenches for concrete–encased ducts the complete length before concrete is laid so that if any obstructions are encountered, proper provisions can be made to avoid them. Place all ducts for concrete encasements on a layer of concrete not less than 3 inches (75 mm) thick prior to its initial set. Where two or more ducts are encased in concrete, space them not less than 1–1/2 inches (37 mm) apart (measured from outside wall to outside wall) using spacers applicable to the type of duct. As the duct laying progresses, place concrete not less than 3 inches (75 mm) thick around the sides and top of the duct bank. Install end bells or couplings flush with the concrete encasement where required.

When specified, reinforce the bottom side and top of encasements with steel reinforcing mesh or fabric or other approved metal reinforcement. When directed, supply additional supports where the ground is soft and boggy, where ducts cross under roadways, or where otherwise shown on the Plans. Under such conditions, support the complete duct structure on reinforced concrete footings, piers, or piles located at approximately 5 foot (1.5 m) intervals.

Do not backfill the excavation until concrete has reached 2,000 psi compressive strength.

Clay or soapstone duct is prohibited.

110–3.3 DUCTS WITHOUT CONCRETE ENCASEMENT (TYPE II). Trenches for single–duct lines shall be not less than 6 inches (150 mm) nor more than 12 inches (300 mm) wide, and the trench for 2 or more ducts installed at the same level shall be proportionately wider. Make trench bottoms for ducts without concrete encasement to conform accurately to grade so as to provide uniform support for the duct along its entire length. Open trenches the complete length before duct is installed.

Place a layer of sand, at least 4 inches (100 mm) thick (loose measurement) or as shown on the Plans, in the bottom of the trench as bedding for the duct. The bedding material shall consist of, sand and shall contain no particles that would be retained on a 1/4–inch (6 mm) sieve. Tamp the bedding material until firm.

Unless otherwise shown in Plans, install ducts in accordance with NFPA 70, but never less than 18 inches below the finished grade.

When two or more ducts are installed in the same trench without concrete encasement, install them as shown on the Drawings.

110–3.4 DUCT MARKERS. Mark The location of the ends of all ducts by a concrete slab marker as shown in the Contract Documents. Locate the markers above the ends of all ducts or duct banks, except where ducts terminate in a handhold, manhole, or building.

Impress the word "duct" and the number and size of ducts beneath the marker on each marker. Show the letters on the Contract Documents.

110–3.5 BACKFILLING. After ducts have been properly installed, backfill the trench in at least two layers with excavated material less than 4 inches (100 mm) in diameter and thoroughly tamped and compacted to at least the density of the surrounding undisturbed soil. If necessary to obtain the desired compaction, the backfill material shall be moistened or aerated.

Trenches shall not be excessively wet and shall not contain pools of water during backfilling operations.

Completely backfill and tamp the trench level with the adjacent surface, except that, when sod is to be placed over the trench, stop the backfilling at a depth equal to the thickness of the sod to be used, with proper allowance for settlement.

Remove and dispose of excess excavated material in accordance with instructions issued by the Engineer.

110–3.6 RESTORATION. Restore turf areas disturbed by the trenching, storing of dirt, cable laying, pad construction and other work. The restoration shall include topsoiling, fertilizing, liming, seeding, and mulching. Perform all Work in accordance with Specifications T–901, T–902, T–904, T–905, and T–908. The Contractor shall be held responsible for maintaining all disturbed surfaces and replacements until final acceptance.

Restore paved areas disturbed by Contractor operations in accordance with the detail shown on the Contract Documents. Material specification and installation shall be in accordance with Standard Specifications.

METHOD OF MEASUREMENT

110–4.1 ELECTRICAL DUCT. Electrical Duct of the various sizes and number of duct indicated, with or without concrete encasement, will be measured on a unit price basis per linear foot. Measurement for payment will be made in a straight horizontal line along the centerline duct installed and accepted.

110–4.2 PAVEMENT RESTORATION Pavement Restoration for Duct Installation will be measured on a unit price basis per linear foot. Measurement for payment shall be made in a straight horizontal line along the centerline of the duct that is located beneath pavement.

110–4.3 DUCT MARKERS. Duct Markers will be measured on a unit price basis per each for markers constructed and accepted.

BASIS OF PAYMENT

110–5.1 Payment will be made at the Contract unit price per linear foot for each type and size of single–way or multi–way duct, completed and accepted. This price will be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete this Item.

a. The Pay Items for Electrical Duct will include excavation, installation, materials, bedding and backfill, compaction, concrete encasement when specified, mandreling, and restoration, except when separate Pay Items are included for pavement restoration.

b. The Pay Item for Duct Markers will include materials and installation.

c. The Pay Item for Pavement Restoration will include the cost of saw cutting, removing and disposing of existing pavement, and placement of subbase, base course, and surface course in accordance with the details included in the Contract Documents.

The cost of restoration of turf, pavement and other features disturbed by installation of duct will be included in prices for Electrical Duct, except when a Pay Item is included for Pavement Restoration in the Schedule of Prices.

Standard Pay Items for Work covered by this Specification are as follows:

Pay Item L11001	Electrical Duct, Type I, 3 inch, 1–way, per lineal foot
Pay Item L11002	Electrical Duct, Type I, 3 inch, 2–way, per lineal foot
Pay Item L11003	Electrical Duct, Type I, 3 inch, 3–way, per lineal foot
Pay Item L11004	Electrical Duct, Type I, 3 inch, 4–way, per lineal foot
Pay Item L11005	Electrical Duct, Type I, 3 inch, 5–way, per lineal foot
Pay Item L11006	Electrical Duct, Type I, 3 inch, 6–way, per lineal foot
Pay Item L11007	Electrical Duct, Type I, 4 inch, 1–way, per lineal foot
Pay Item L11008	Electrical Duct, Type I, 4 inch, 2–way, per lineal foot
Pay Item L11009	Electrical Duct, Type I, 4 inch, 3–way, per lineal foot
Pay Item L11010	Electrical Duct, Type I, 4 inch, 4–way, per lineal foot
Pay Item L11011	Electrical Duct, Type I, 4 inch, 5–way, per lineal foot
Pay Item L11012	Electrical Duct, Type I, 4 inch, 6–way, per lineal foot
Pay Item L11013	Electrical Duct, Type II, 3 inch, 1–way, , per lineal foot
Pay Item L11014	Electrical Duct, Type II, 3 inch, 2–way, , per lineal foot
Pay Item L11015	Electrical Duct, Type II, 3 inch, 3–way, , per lineal foot
Pay Item L11016	Electrical Duct, Type II, 3 inch, 4–way, , per lineal foot
Pay Item L11017	Electrical Duct, Type II, 3 inch, 5–way, per lineal foot
Pay Item L11018	Electrical Duct, Type II, 3 inch, 6–way, , per lineal foot
Pay Item L11019	Electrical Duct, Type II, 4 inch, 1–way, , per lineal foot
Pay Item L11020	Electrical Duct, Type II, 4 inch, 2–way, , per lineal foot
Pay Item L11021	Electrical Duct, Type II, 4 inch, 3–way, , per lineal foot
Pay Item L11022	Electrical Duct, Type II, 4 inch, 4–way, , per lineal foot
Pay Item L11023	Electrical Duct, Type II, 4 inch, 5–way, , per lineal foot
Pay Item L11024	Electrical Duct, Type II, 4 inch, 6–way, , per lineal foot
Pay Item L11025	Duct marker, per each
Pay Item L11026	Pavement Restoration for Duct Installation, per lineal foot

Measurement and Payment will only be made for Pay Items included in the Schedule of Prices. The cost of all Work required by the Contract Documents will be included in the Pay Items contained in the Schedule of Prices.

SPECIFICATION L–119. INSTALLATION OF AIRPORT OBSTRUCTION LIGHTS AND FLASHING RED BEACON L–810, L–856, L–857, L–864, L–865, L–866, and L-885

DESCRIPTION

119–1.1 GENERAL.

a. This Work consists of furnishing and installing obstruction lights in accordance with the Contract Documents, and shall include furnishing and installing poles, steel or iron pipes, structures, or other supports as required in the Contract Documents, and mounting, leveling, conduit, wiring, and power source. This Work also includes all wire and cable connections, the furnishing and installing of all necessary conduits and fittings, insulators, pole steps, and the painting of poles and pipes. In addition, it includes the furnishing and installing of all lamps and the servicing and testing of the installation and all incidentals necessary to place the lights in operation as completed units. This Work includes an Electric Utility Service and treated wood pole, if specified in the Contract Documents.

119-1.2 THIS SPECIFICATION INCLUDES:

a. Regulatory Requirements.
b. Obstruction Lights.
c. Isolation Transformers.
d. Transformer Housings.
e. Paint.
f. Flasher.

119-1.3 OTHER RELATED SPECIFICATIONS.

a. L-100-1.1 through L-100-2.17 General Requirements.
b. L-100-3.2 Raceways.
c. L-100-3.3 Feeder and Branch Circuit Wire and Cable.
d. L-100-3.4 Control and Signal Wire and Cable.
e. L-100-3.5 Electrical Boxes and Fittings.
f. L-100-3.6 Wiring Devices.
g. L-100-3.7 Cabinets and Enclosures.
h. L-100-3.8 Supporting Devices.
i. L-100-3.9 Electrical Identification.
j. L-100-3.12 Overcurrent Devices.

119-1.4 CLASSIFICATIONS.

a. L-810 Steady Burning Red Obstruction Light.
b. L-856 High Intensity Flashing White Obstruction Light, 40 flashes per minute.
c. L-857 High Intensity Flashing White Obstruction Light, 60 flashes per minute.
d. L-864 Flashing Red Obstruction Light, 20-40 flashes per minute.
e. L-865 Medium Intensity Flashing White Obstruction Light, 40 flashes per minute.
f. L-866 Medium Intensity Flashing White Obstruction Light, 60 flashes per minute.
g. L-885 Flashing Red Obstruction Light, 60 flashes per minute.
h.

NOTE TO SPECIFIER:
Refer to AC 70/746- for obstruction lighting specifications.

EQUIPMENT AND MATERIALS

119–2.1 REGULATORY REQUIREMENTS..

a. Airport lighting equipment and materials requiring Federal Aviation Administration (FAA) specifications shall have the prior approval of the FAA, and be listed in the latest edition of Advisory Circular (AC) 150/5345–53 Appendix 3.

b. All other electrical equipment and materials shall be subject to acceptance through manufacturer's certification of compliance as required by Specification L–100.

119–2.2 OBSTRUCTION LIGHTS. The obstruction lights shall conform to the requirements of AC 150/5345–43, Specification for Obstruction Lighting Equipment.

119–2.3 ISOLATION TRANSFORMERS. Where required for series circuits, the isolation transformers shall conform to the requirements of AC 150/5345–47, Isolation Transformers for Airport Lighting Systems.

119–2.4 TRANSFORMER HOUSING. Transformer housings, if specified, shall conform to AC 150/5345–42, Specification for Airport Light Base and Transformer Housings, Junction Boxes, and Accessories.

119–2.3 PAINT.

a. Priming paint for aluminum and ungalvanized metal surfaces, and the mixing thereof, shall conform to ASTM D 83.

b. Use zinc dust-zinc oxide primer paint for galvanized metal surfaces, conforming to Fed. Spec. TT–P–641.

c. Use a ready-mixed nonfading Orange paint for the body and the finish coats on metal and wood surfaces, meeting the requirements of Fed. Spec. TT–P–59. The color shall be in accordance with Federal Standards 595, Aviation Gloss Orange Number 12197.

d. Use ready-mixed white paint for body and finish coats on metal and wood surfaces conforming to Fed. Spec. TT–P–102.

e. Mix priming paint for wood surfaces on the job by thinning the previously specified orange or white paint by adding 1/2 pint (0.06 liters) of raw linseed oil to each gallon (liter).

f. Paint, poles, pole steps, and all other miscellaneous materials necessary for the completion of this Item shall be new and first–grade commercial products. These products shall be as specified in the Plans or Specifications.

119–2.4 FLASHER. The beacon flasher for the L–864 obstruction light shall be a standard commercially available unit designed for the service intended. The mechanism in the flasher shall be designed to flash not more than 40 and not less than 12 flashes per minute. The flashing switch shall be of the mercury contact–type encapsulated in nonbreakable plastic. The entire unit shall be housed in a weatherproof cabinet.

CONSTRUCTION METHODS

119–3.1 PLACING THE OBSTRUCTION LIGHTS. Furnish and install obstruction lights as specified and shown in the Contract Documents. Mount the obstruction lights on poles, buildings, towers or beacon structures at the location shown in the Contract Documents. Install the power source and the electric utility service at the locations indicated in the contract documents.

119–3.2 INSTALLATION ON POLES. Where obstruction lights are to be mounted on poles, install each obstruction light with its hub at least as high as the top of the pole. Run all conductors in not less than 1–inch (25 mm) galvanized rigid steel conduit. If specified, furnish and install pole steps, the lowest step being 5 feet (1.5 m) above ground level. Install steps alternately on diametrically opposite sides of the pole to give a rise of 18 inches (450 mm) for each step. Fasten conduit to the pole with galvanized steel pipe straps and secure by stainless round head wood screws. Paint poles as shown in the Plans and Specifications.

When obstruction lights are installed on existing telephone or power poles, install a large fiber insulating sleeve over the conduit to the obstruction light, and extend it 6 inches (150 mm) above the conductors on the upper crossarm. In addition, the sleeve shall be at least 18 inches (450 mm) below the conductors on the lower crossarm. The details of this installation shall be in accordance with the plans.

119–3.3 INSTALLATION ON BEACON TOWER. Where obstruction lights are installed on a beacon tower structure, mount two obstruction lights on top of the beacon tower using 1–inch (25 mm) conduit. Screw the conduit directly into the obstruction light fixtures and support them at a height of not less than 4 inches (100 mm) above the top of the rotating beacon. The obstruction lights at the lower levels of a tower, shall be 1/2–inch (12 mm) galvanized rigid steel conduit with standard conduit fittings for mounting the fixtures. Mount the fixtures in an upright position in all cases. Fasten the conduit to the tower members with "wraplock" straps, clamps, or approved fasteners spaced approximately 5 feet (1.5 m) apart. Apply three coats of aviation–orange paint (one prime, one body, and one finish coat) to all exposed material installed including conduit and straps and clamps.

119–3.4 INSTALLATION ON BUILDINGS, TOWERS, SMOKESTACKS, AND SIMILAR STRUCTURES. Where obstruction lights are to be installed on buildings or similar structures, installing accordance with details shown in the Contract Documents. The hub of the obstruction light shall be not less than 1 foot (300 mm) above the highest point of the obstruction except in the case of smokestacks where the uppermost units shall be mounted not less than 5 feet (1.5 m), nor more than 10 feet (3 m) below the top of the stack. Fasten conduit supporting the obstruction light units to wooden structures with galvanized steel pipe straps and secure by 1–1/2 inch (37 mm) No. 10 stainless round head wood screws. Fasten conduit to masonry structures using expansion shields, screw anchors, or toggle bolts using No. 10, or larger, stainless

round head or machine screws. Conduit fastened to structural steel shall have the straps held with not less than No. 10 roundhead machine screws in drilled and tapped holes. Fastenings shall be approximately 5 feet (1.5 m) apart. Apply three coats of aviation–orange paint (one prime, one body, and one finish coat) to all exposed material installed including conduit straps and clamps.

119–3.5 FLASHER. If required in the Contract Documents, install a separate flashing mechanism for the L–864 obstruction light adjacent or near the L–864 obstruction light. Design the mechanism in this flasher to flash not more than 40 and not less than 12 flashes per minute.

119–3.6 SERIES ISOLATION TRANSFORMERS. If the obstruction light is powered from a constant current regulator, an isolation transformer is required with each series lamp. Double series units of this type require two series isolation transformers. The transformer shall be housed in a base or buried directly in the earth in accordance with the details shown in the Contract Documents.

119–3.7 ELECTRICAL. Furnish all necessary labor and materials and make complete electrical connections from the underground cable or other source of power in accordance with the Contract Documents.

119–3.8 LAMPS. Furnish and install one or two lamps in each unit, as required, conforming to the following requirements:

a. Series lamp—6.6 ampere, 1020–lumen, a–21 clear bulb, medium prefocus base.

b. Multiple lamp—100, 107, or 116 watts; 115, 120, or 125 volts; a–21 clear bulb, medium screw base.

119–3.9 TESTS. The installation shall be fully tested by continuous operation for not less than 1/2 hour as a completed unit prior to acceptance. These tests shall include the functioning of each control not less than 10 times.

METHOD OF MEASUREMENT

119–4.1 Airport Obstruction Lighting and Electric Utility Service will be measured as complete units per lump sum at locations indicated in the Contract Documents.

BASIS OF PAYMENT

119–5.1 Payment will be made at the Contract price per lump sum for the Classification of Airport Obstruction Lights, at the locations indicated, complete and accepted.

Payment will be made at the Contract price per lump sum for the Electric Utility Service, at the locations indicated, complete and accepted.

These prices will be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the Work.

a. Airport Obstruction Lights will include the obstruction light equipment, lamps, hardware attachments, pole mounting, leveling, conduit, wiring, power source, photoelectric control, ground rods, and servicing and testing of the Obstruction Lights, all in accordance with the Contract Documents.

b. The Electric Utility Service will include the utility meter, meter enclosure, main service switch, pull box, photocell contactor or controller, if required, conduit wire, attachment structure, concrete pad, excavation, and backfill, all in accordance with the contract documents and in particular L-100-2.2 and L-10-0-2.3

Standard Pay Items for Work covered by this Specification are as follows:

Pay Item L11901 through L11910	Obstruction lighting, L–810, Location No. ___, per lump sum
Pay Item L11911 through L11920	Obstruction lighting, L–856, Location No. ___, per lump sum
Pay Item L11921 through L11930	Obstruction lighting, L–857, Location No. ___, per lump sum
Pay Item L11931 through L11940	Flashing Red Beacon, L–864, Location No. ___, per lump sum
Pay Item L11941 through L11950	Obstruction lighting, L–865, Location No. ___, per lump sum
Pay Item L11951 through L11960	Obstruction lighting, L–866, Location No. ___, per lump sum
Pay Item L11960	Obstruction lighting, L-885, Location No. ___, per lump sum
Pay Item L11961	Electric Utility Service, Location No. ____, per lump sum

Measurement and Payment will only be made for Pay Items included in the Schedule of Prices. The cost of all Work required by the Contract Documents will be included in Pay Items contained in the Schedule of Prices.

MATERIAL REFERENCE

AC 150/5345-42	Specification for Airport Light Base and Transformer Housings, Junction Boxes, and Accessories
AC 150/5345-43	Specification for Obstruction Lighting Equipment

SPECIFICATION L–125. INSTALLATION OF AIRPORT LIGHTING SYSTEMS

DESCRIPTION

125–1.1 GENERAL.

a. This Work consists of Airport lighting systems furnished and installed in accordance with this Specification, the referenced Specification, and the applicable Advisory Circulars. The systems are installed at the location and in accordance with the dimensions, design, and details shown in the Contract Documents. This Work includes furnishing of all equipment, materials, services, and incidentals necessary to place the systems in operation as completed units.

125-1.2 THIS SPECIFICATION INCLUDES:

a. Regulatory Requirements.
b. Runway and Taxiway Edge Lights.
c. Guidance Signs.
d. Transformer Access Handhole.
e. Runway End Indicator Light System (REILS).
f. Precision Approach Path Indicator System (PAPIS).
g. Isolation Transformers.
h. Retroreflective Markers.
i. Cable Connectors.
j. Base Cans.

L-125-1.3 OTHER RELATED DOCUMENTS.

a. L-100-1.1 through L-100-2.17 General Requirements.
b. L-100-3.2 Raceways.

L-125-1.4 CLASSIFICATIONS.

a. L-860 Runway edge, VFR runways, Omnidirectional: white, Bidirectional: white-red, white-green
b. L-860E Runway threshold/end, Bidirectional: red-green, red-red, VFR runways, Unidirectional green
c. L-861 Runway edge, non-precision, Omnidirectional: white, IFR runways, Bidirectional: white-yellow, white-red, yellow-red, white-green
d. L-861E Runway threshold/end, Bidirectional: red-green, red-red, non-precision IFR runways, Unidirectional: green
e. L-861SE Runway threshold/end, Bidirectional: red-green, non-precision IFR runways, Unidirectional: green
f. L-861T Taxiway edge, Omnidirectional: blue
g. L-862 Runway edge, precision, Bidirectional: white-white, white-yellow, IFR runways, white-red, yellow-red, white-green
h. L-862E Runway threshold/end, Bidirectional: red-green, red-red, precision IFR runways, Unidirectional: green
i. L-804 Holding position edge, Unidirectional: yellow: flashing
j. L-849 REILS, Style A, Unidirectional, high intensity, one brightness stop, REILS, Style B, Omnidirectional, high intensity, one brightness step, REILS, Style C, Unidirectional, low intensity, one brightness step, REILS, Style D, Omnidirectional, low intensity, one brightness step, REILS, Style E, Unidirectional, three brightness steps
k. L-880 PAPI, 4 light unit, L-881 PAPI, 2 light unit, Style A, Voltage powered unit, Style B, Current powered unit, Class I, Operation to -35°C, Class II, Operation to -55°C
l. L-853 Retroreflective Marker, Type 1, Semi-flush for centerline machine, Type 2, Elevated marker for edge marking, Style 1, Snow plowable (Type 1 only), Style 2, Non snow plowable (Type 1 only)
m. L-858 Signs Refer to the drawing legend and schedules

EQUIPMENT AND MATERIALS

125–2.1 REGULATORY REQUIREMENTS.

a. Airport lighting equipment and materials requiring FAA specifications shall have the prior approval of the Federal Aviation Administration, and be listed in the latest edition of Advisory Circular (AC) 150/5345–53, Appendix 3.

b. All other electrical equipment and materials shall be subject to acceptance through the manufacturer's certification of compliance as required in Specification L–100.

125-2.2 RUNWAY AND TAXIWAY EDGE LIGHTS. The runway and taxiway edge lights shall conform to the most recent edition of AC 150/5345-46.

125-2.3 GUIDANCE SIGNS. The guidance signs shall conform to the most recent edition of AC 150/5345-44.

125-2.4 TRANSFORMER ACCESS HANDHOLE. The transformer access handhole shall be non-metallic with replaceable lid, UL listed for two purpose.

125-2.5 REILS. The REILS shall conform to the most recent edition of AC 150/5345-51.

125-2.6 PAPIS. The PAPIS shall conform to the most recent edition of AC 150/5345-28D.

125-2.7 ISOLATION TRANSFORMERS. The isolation transformers shall conform to the most recent edition of AC 150/5345-47.

125-2.8 RETROREFLECTIVE MARKERS. The retroreflective markers shall conform to the most recent edition of AC 150/5345-39.

125-2.9 CABLE CONNECTORS. The cable connectors shall conform to the most recent edition of AC 150/5345-26.

125-2.10 BASE CANS. The base cans shall conform to the most recent edition of AC 150/5345-42.

CONSTRUCTION METHODS

125–3.1 LIGHTING SYSTEMS.. Install the lighting systems at the location indicated in the Contract Documents. Install the power source and electric utility service at the location indicated in the Contract Documents.

125–3.2 GROUNDING STAKE MOUNTED LIGHTING FIXTURES. Grounding stake mounted fixtures consists of grounding all edge lighting fixtures mounted on angle stakes, including all labor and materials for the grounding electrode conductor, stake grounding connection, and inspecting the system electrode grounding conductor and exothermic weld.

Install the system grounding electrode conductor to all stakes prior to the installation of the stakes so that the conductor lengths and exothermic welds can be inspected at one time. Splices are not allowed in the grounding electrode conductor.

All edge lighting mounting provision shall be metal so that the electrical ground continuity is continuous from the light fixture housing, through the fixture stem, frangible coupling, to the iron mounting stake. Plastic components are not allowed anywhere in the fixture to stake assembly.

125–3.3 GROUNDING L–867 BASE CANS. Grounding of L–867 base cans consists of grounding all L–867 base cans for edge lighting fixtures, REIL's, taxiway guidance signs, and L–867 base cans used as junction boxes including all labor and materials for the grounding electrode conductor, base can grounding connection, and inspecting the system electrode grounding conductor and ground lug connection.

Install the system grounding electrode conductor to all cans prior to the installation of the base cans, so that the conductor lengths and compression connections can be inspected at one time. Splices are not allowed in the grounding electrode conductor.

The cable lug shall be a UL listed copper compression connector, Thomas and Betts, Burndy, Blackburn, or equal. Attach the connector to the can with a separate self locking nut/bolt arrangement compatible with the can manufacturer's ground mounting provision. Use the manufacturer's approved mechanical indentor tool for installing the compression connector. Torque the bolted connection to the factory grounding provision for adequate bond. Stripped threads will be a cause for rejection.

When the L–867 can is used as a mounting provision for an edge light, the mounting provision shall be metal so that the electrical ground continuity is continuous from the light housing, through the housing stem, frangible coupling, to the L–867 base can. Plastic components are not allowed anywhere in the fixture to base can assembly.

125–3.4 GROUND RODS FOR REGULATOR SECONDARY 5KV LIGHTING CIRCUITS. Ground the regulator secondary circuit according to the Contract Documents.

a. Standard Grounding Method. The standard grounding method consists of two ground rods 5/8" diameter x 8–foot long, for the purpose of connecting it to the grounding electrode conductor as noted on the Drawings.

b. Connect the ground rods to the grounding electrode conductor by exothermic welds or other FAA approved grounding connection.

NOTE TO SPECIFIER:
If the alternate method of grounding is desired, it should be specified in the Special Provisions.

Alternate Grounding Method: When specified in the Special Provisions, the alternate method for grounding lighting circuits described in the following paragraphs shall be used.

The test shall include Contractor supplied manpower and test equipment to test each grounding system. The test instrument shall be a 3 pole ground resistance tester, AEMC, Biddle, or equal, as approved by the Engineer, with a ±5% or better accuracy for 10% to 100% of 0–50 ohm scale range, accompanied by formal proof that the instrument has been calibrated for accuracy, no more than 30 days prior to the test date for this Pay Item. Clamp on testers and high resistance fault locators are not acceptable.

The test shall achieve a maximum 25 ohms less 5% (23.75 ohms) to ground with each installation beginning with one 8-foot length installed and tested. If 23.75 ohms are not attained on the first rod, install additional lengths and test again until no more than 23.75 ohms is achieved. Ground rod shall be 5/8" diameter x 8 feet long sectional type copper clad steel. Ground rod installation shall comply with all the requirements of the latest edition of NFPA Section 70, specifically, Article 250, Section H, J, and K.

Exothermic weld or use other FAA approved grounding connector to connect the grounding electrode conductor to the ground rod below the coupling thread line. The Contractor will be paid only once for this connection. More specifically, the Contractor will only be paid for one grounding electrode conductor weld per ground rod. The Contractor will not be paid for more than one weld per rod length as a result of a faulty weld performance or damage as a result of careless installation. When more ground rod lengths are added to achieve the specified resistance, the Contractor shall cut the conductor off the previous rod and reattach the conductor to the end of the added rod. After each consecutive ground rod section is installed in place, reweld the electrode conductor, and retest to determine the specified resistance. Use a threaded coupling and driving stud to protect the ground rod threads during the installation of the ground rod. When the rod is installed in a L–867 can base, weld the grounding electrode conductor before the rod is driven past the top elevation of the can base. Leave exposed all exothermic welds to ground rods at stake mounted fixtures until tested.

Develop a log identifying the final resistance value for each grounding system, signed by both the Contractor and the witness, and copied for the Engineer. As a minimum, include in the log the name of the Airport, the name and model number of the test instrument, the project number, the date of the test, a tag number for each test location, coordinated with the record drawing, number of ground rod lengths at each location, final resistance values, and place for witness and Contractor signature.

METHOD OF MEASUREMENT

125–4.1 Lights. Runway and Taxiway Edge Lights, and Threshold End Lights will be measured for payment on a unit basis per each.

125–4.2 Runway and Taxiway Signs, Retroreflective Markers, Handholes, and Removals will be measured for payment on a unit basis per each.

125–4.3 Measurement for removal of edge light fixtures and signs will be for the quantity removed.

125-4.4 Electric utility service will be measured as complete units per lump sum at locations indicated in the Contract Documents.

BASIS OF PAYMENT

125–5.1 Payment will be made at the Contract unit price for each complete Lighting System, Retroreflective Marker, Light, Sign, Handhole, and Removal Item, of the type indicated, installed in place by the Contractor and accepted by the Engineer. This price will be full compensation for furnishing all materials and for all preparation, assembly, and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete this Work.

a. Lights. Light units include fixtures, stems, frangible couplings, stakes or L–867 base cans, can lids, gasket, isolation transformer, grounding, connections to the system, testing, and incidental items required to provide a functioning unit in accordance with the Contract Documents. Base cans (bases) include excavation, backfill, restoration, cans, gaskets, conduit, concrete, and conduit hubs and other items shown on details or required for a complete unit, all in accordance with the Contract Documents.

b. Signs. Sign units include modules of the type specified, concrete pad, L–867 base cans, can lids, gaskets, conduit, excavation, backfill, isolation transformers, grounding, restoration, connection to the system, testing, excavation, backfill, restoration, conduit and conduit hubs, and other incidental items required for a complete unit, all in accordance with the Contract Documents.

c. Replacement sign panels include panels, appurtenant items and installation.

d. Removal. Removals include disconnection from the electrical system, maintaining and restoring the electrical system service if required, site restoration and disposal of materials.

e. REILS and PAPIS. The REILS and PAPIS include fixtures, stems, frangible couplings, L-867 base cans, can lids, gaskets, power adapters, master/slave controllers, wire, cable, conduit testing, system connectors, foundations, excavating, backfill, restoration, and other items, all in accordance with the Contract Documents.

f. The Electric Utility Service shall include the utility meter, meter enclosure, main service switch, pull box, photocell contactor or controller if required, conduit wire, attachment structure, concrete pad, excavation, and backfill, all in accordance with the Contract Documents and particular, L-100-2.2 and L-100-2.3.

Standard Pay Items for Work covered by this Specification are as follows:

Pay Item L12501	Retroreflective Marker, L-853, Type 1, Style 1
Pay Item L12502	Retroreflective Marker, L-853, Type 1, Style 2
Pay Item L12503	Retroreflective Marker, L-853, Type 2
Pay Item L12504	Low Intensity Runway Lights, L-860, Stake Mounted, per each
Pay Item L12505	Low Intensity Runway Threshold Lights, L-860E, Stake Mounted, per each
Pay Item L12506	Medium Intensity Runway Lights, L-861, Stake Mounted, per each
Pay Item L12507	Medium Intensity Runway Lights, L-861, Base Mounted, per each
Pay Item L12508	Medium Intensity Runway Threshold Light, L-861E, Stake Mounted, per each
Pay Item L12509	Medium Intensity Threshold Light, L-861E, Base Mounted, per each
Pay Item L12510	Medium Intensity Taxiway Light, L-861T, Stake Mounted, per each
Pay Item L12511	Medium Intensity Taxiway Light, L-861T, Base Mounted, per each
Pay Item L12512	High Intensity Runway Light, L-862, Base Mounted, per each
Pay Item L12513	High Intensity Runway Threshold Light, L-862E, Base Mounted, per each
Pay Item L12514	L-867 Base Can with Lid and Gasket, per each
Pay Item L12515	Remove Runway or Taxiway Stake Mounted Light, per each
Pay Item L12516	Remove Runway or Taxiway Base Mounted Light, per each
Pay Item L12517	Guidance Sign, 1-Module, per each
Pay Item L12518	Guidance Sign, 2-Module, per each
Pay Item L12519	Guidance Sign, 3-Module, per each
Pay Item L12520	Guidance Sign, 4-Module, per each
Pay Item L12521	Extend Guidance Sign, 1-Module, per each
Pay Item L12522	Replace Guidance Sign Legend Panel, per each
Pay Item L12523	Distance Remaining Sign, per each
Pay Item L12524	Transformer Access Handhole, per each
Pay Item L12525	Remove Taxiway Guidance Sign, per each
Pay Item L12526	REILS Constant Voltage L-849, Style A, per lump sum
Pay Item L12527	REILS Constant Voltage L-849, Style B, per lump sum
Pay Item L12528	REILS Constant Voltage L-849, Style C, per lump sum
Pay Item L12529	REILS Constant Voltage L-849, Style D, per lump sum
Pay Item L12530	REILS Constant Voltage L-849, Style E, per lump sum
Pay Item L12531	REILS Constant Current L-849, Style A, per lump sum
Pay Item L12532	REILS Constant Current L-849, Style B, per lump sum
Pay Item L12533	REILS Constant Current L-849, Style C, per lump sum
Pay Item L12534	REILS Constant Current L-849, Style D, per lump sum
Pay Item L12535	REILS Constant Current L-849, Style E, per lump sum
Pay Item L12536	PAPI L-880, Style A, Class I, per lump sum
Pay Item L12537	PAPI L-880, Style A, Class II, per lump sum
Pay Item L12538	PAPI L-880, Style B, Class I, per lump sum
Pay Item L12539	PAPI L-880, Style B, Class II, per lump sum
Pay Item L12540	PAPI L-881, Style A, Class I, per lump sum
Pay Item L12541	PAPI L-881, Style A, Class II, per lump sum
Pay Item L12542	PAPI L-881, Style B, Class I, per lump sum
Pay Item L12543	PAPI L-881, Style B, Class II, per lump sum
Pay Item L12544 through L12555	Electric Utility Service, Location No. ____, per lump sum

Measurement and Payment will be made for Pay Items included in the Schedule of Prices. The cost of all Work required by the Contract Documents will be included in Pay Items contained in the Schedule of Prices.