ELECTRICAL TECHNICAL PAPER 21
VISUAL AIR NAVIGATION FACILITIES: AIR FACILITY EQUIPMENT INSPECTION AND TESTING

Information in this technical paper was excerpted from previous versions of UFC 3-535-01. This information has been updated to reflect current practices and technology.

1.0 CONTRACTUAL ACCEPTANCE TESTS.

Test and inspect during construction and before accepting and placing a new system into service to ensure the system is operating properly and has been constructed as designed. The government will conduct a commissioning flight inspection on all light systems covered by AFMAN 11-225 (I). Establish responsibility for any deficiencies found and complete corrective action before releasing the construction contractor. This chapter applies to inspection and testing during construction and the contractual acceptance tests of new installations. Include the applicable contractual test procedures in the contract specifications. If the installation is not accomplished by contract, perform the tests before making the system operational.

1.0.1 Electrical Safety.

Most airfield lighting circuits and power supply equipment operate at high voltages. Qualified personnel, who are familiar with high voltage electrical equipment and the safety precautions that must be observed, must perform the tests defined in this chapter. The following are general safety precautions that apply to all work in or around electrical equipment, and specifically for series lighting circuits. Understand and apply these precautions during all phases of operation and maintenance, whether working in the lighting vault or on the field circuits. Additional safety information can be found in: EM 385-1-1, FAA AC 150/5340-26, and UFC-3-560-01.

1.0.1.1 Two Basic Rules.

1.0.1.1.1 Work should never be performed on energized electrical conductors or equipment, except for measuring voltage or current. Lock out equipment if it is not easily visible from the work site.

1.0.1.1.2 Always assume that power is on until the true condition is determined.

1.0.1.2 Safety Practices.

1.0.1.2.1 All commercial test equipment should be UL approved.

1.0.1.2.2 Prior to beginning work on airport lighting circuits, coordinate work schedule with Tower. Obtain authorization for local control.

1.0.1.2.3 If work is on high voltage circuit (480V or higher for purposes of this document), at least two electricians should be present, one having thorough knowledge of high voltage circuits. Observer should: keep other personnel not involved in work clear of equipment, be familiar with power disconnects and immediately disconnect power source in case of emergency, be qualified in first aid, and observe work to detect and warn against unsafe practices.

1.0.1.3 **Personal Safety Precautions.**

- Know location of main power disconnect devices.
- Know how to summon medical aid.
- De-energize circuits using proper procedures.
- Verify that voltage is off by using a voltmeter on the component after opening the power switch.
- Insulate feet by standing on a dry rubber mat. Remember that contact with the grounded equipment cabinet could nullify this protection.
- Stay clear of terminals, leads, or components that carry voltages of any magnitude. Avoid contact with components that are grounded, including frame.
- Be certain there is no power applied to a circuit when making continuity or resistance check (meter will be damaged).
- Ensure that both the test equipment and the equipment under test are properly grounded.
- Do not wear jewelry, wristwatches, or rings while working with electrical equipment.
- Keep clothing, hands, and feet dry if at all possible.
- Use the correct tool for doing the job.
- Never use toxic or flammable solvents for cleaning purposes.
- Where air pressure is required for cleaning, use low-pressure (30 psi (206 kPa) or less) air source. Use eye protection with compressed air.
- Goggles and safety shoes should be worn when around high voltage.
- Never compromise safety.

1.0.1.4 Common Causes of Accidents.

- Working on equipment without adequate coordination with user.
- Working on equipment without sufficient experience on that equipment.
- Failure to follow instructions in equipment manuals.
- Failure to follow safety precautions.
- Using unsafe equipment.
- Failure to use safety devices.
- Working at unsafe speeds.
- Poor housekeeping of work areas.

1.1 GUARANTEE PERIOD.

Each installation contract will include a guarantee or warranty clause. It must specify a period of at least one year, after acceptance, during which the installation contractor is responsible for repairing and replacing, without charge, all cable or equipment failures resulting from poor work performance or defective materials and equipment. System failure can occur within months after installation due to faulty installation practices.

1.2 VISUAL EXAMINATION.

Thorough visual inspections are the most important of all inspection and test procedures. Visual inspections must be made frequently during installation, at the completion of installation, and before energizing the circuits. A careful visual inspection will reveal defects that should be corrected before acceptance tests and energizing. Serious damage may occur if defects are subjected to electrical tests or energizing. Visual inspections will include: correctness of external connections, good workmanship, cleanliness, recognition of safety hazards, and any specific requirements for individual items. All equipment manufactured under specifications pass strict factory tests before shipment, but it must be inspected for shipping damage immediately upon receipt.

1.2.1 Visual Inspection Checklists.

Table 1 through Table 8 provide checklists that can be used for visual inspection, during installation and as part of acceptance procedures, for various components and subsystems. Similar lists are recommended for items not included in Table 1, Table 2, Table 3, Table 4, Table 5, Table 6, Table 7 and Table 8 below.

Table 1. Checklist for High Intensity Runway Lighting (Elevated, Base Mounted)

Bases

_____ 1. Are transformer housings of the correct type, size and material?

_____ 2. Are transformer bases installed level, to proper grade, and with proper bolt pattern orientation?
[Tops of transformer housings should be slightly above surrounding grade in non-paved areas, or flush with grade in paved areas (to keep water away from covers). There should be smooth transition between concrete envelope and surrounding grade. Allowances must be made for spacer rings or pavement rings where used.]

_____ 3. Are transformer base cover gaskets properly installed, with all bolts properly torqued? [Use only stainless steel bolts; do not reuse shipping bolts unless so intended by the manufacturer.]

Lights

_____ 4. Are all equipment and materials new, and as specified? Are lamps and isolation transformers of proper wattage? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53.]

_____ 5. Are all light locations in accordance with the plans?

_____ 6. Are the correct filters installed and light lenses properly oriented for runway edge lights? For threshold/end lights?

_____ 7. Are the light lines at proper distance from the pavement or defined edge, in straight line within tolerance?

_____ 8. Is the height of light fixtures in accordance with the plans, and breakable couplings properly installed?

_____ 9. Are all lights plumb and are their heads tight and level? Are bidirectional lights properly oriented relative to the runway? [Bidirectional lights have toe-in and must be oriented properly relative to runway.]

Cables

_____ 10. Are L-823 connectors of proper size for the cable, and are field attached connectors applied properly per details (taping/heat shrink)?

_____ 11. Are all L-823 Type II two conductor secondary connectors Class A (factory molded)?

_____ 12. Has grounding of light base been provided in accordance with the plans? Are ground rods installed to at least minimum depth below grade and within maximum spacing?

_____ 13. Is counterpoise properly separated from light bases and base grounding provisions? [The counterpoise/grounding policy may not be the same at each air base. Ensure compliance with plans.]

System

_____ 14. Are lights labeled in accordance with approved numbering scheme, with proper tag and size of numerals? Are edge light numbering tags facing the pavements?

_____ 15. Are all new lights operational? Is there any visual evidence of dimming?

_____ 16. Have installed fixtures passed photometric testing standards?

Table 2. Checklist for In-pavement Lights (1 of 2)

Progress Inspection

____1. Are all equipment and materials new, and as specified? Are transformer housings of the correct type, size and material? Are lamps of proper wattage? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53.]

____2. Are the recesses for in-pavement lights or light bases being located within the allowable dimensional tolerances?

____3. Is the coring and sawing equipment capable of producing acceptable recesses and kerfs?

____4. Is the recess diameter and depth in accordance with the plans? Is the width and depth of the saw kerfs in accordance with contract requirements?

____6. Are the in-pavement light base jigs capable of accurate receptacle/light base alignment and of holding the receptacle/light base firmly during pouring and curing of concrete?

____7. Are the light bases being aligned and leveled within the allowable tolerances, and receptacles/light bases being installed at proper elevation? [Tops of transformer housings must be proper depth below grade, depending on type of fixture and allowance for spacers and pavement ring, as required by plans and manufacturer's instructions.]

____8. If epoxy is required:

- Has the epoxy manufacturer supplied adequate and clear instructions for mixing, handling, and installation of the material, and are the instructions being followed?
- Is material being machine mixed, and are sample tests of the epoxy being made?
- Are the temperatures (air and pavement) within allowable tolerances for the type of epoxy being used?

____9. Are the ends of all wires sealed when they are not being immediately connected?

____10. Are the L-823 connectors of proper size and do they properly fit the cable?

____11. Has taping/heat shrink for field attached connectors been applied properly, per details?

____12. Are the plywood or steel covers kept on the light bases until just before installation of the light fixture in order to prevent entry of any foreign matter?

____13. Are the receptacles/light bases cleaned and dried before installation of the light fixtures?

____14. Are all bolts of stainless steel and torqued per manufacturer's instructions?

____15. Has grounding of light base been provided in accordance with the plans?

____16. Where secondary wires are installed in conduit which is epoxy sealed in saw kerfs:

____ a. Is the width and depth of the saw kerfs as required by plans?

____ b. Are the recesses and saw kerfs properly sand blasted, cleaned, and dried just before installation and sealing of the conduit or wire?

Table 2. Checklist for In-pavement Lights (Cont., 2 of 2)

____	c. Is the conduit or wire properly secured in the saw kerf before adding the epoxy? [acceptable wedges at proper spacing.]
____	d. If required, is flexible conduit used to terminate rigid conduit at the base?
____	e. Are expansion joints installed in conduit where required?
____	f. Are the secondary wires before sealing and connecting to transformers being tested for insulation resistance and continuity, and are the results acceptable and being recorded?
____	17. Have installed fixtures passed photometric testing standards?
	Final Inspection
____	1. Are all the lenses clean and dry?
____	2. Are colored filters installed in accordance with the plans?
____	3. Are the L-823 connectors of proper size and do they properly fit the cable?
____	4. Has taping/heat shrink for field attached connectors been applied properly, per details?
____	5. Are base spacers, rings, gaskets installed for correct elevation relative to pavement, and are bolts securing fixture stainless steel and properly torqued?
____	6. Has all excess epoxy been removed so that no epoxy is left above the pavement? Have all dams at rigid pavement joints been removed from the kerfs before pouring the pavement joint sealer?
____	7. Is the level of epoxy and joint sealer around the lights and in the saw kerfs in accordance with plans and specifications? [Epoxy should not be allowed to contact and bond to edge of fixture.]
____	8. Are the bases dry? Water in bases may be unavoidable due to high ground water or other conditions, and design may include drainage provisions. If so, are drainage provisions in place and functional?
____	9. Are all the lights operating?

Table 3. Checklist for Medium Intensity Runway and Taxiway Lighting (Elevated, Base Mounted)

Bases

_____1. Are transformer housings of the correct type, size and material?

_____2. Are transformer bases installed level, to proper grade, and with proper bolt pattern orientation?
[Tops of transformer housings should be slightly above surrounding grade in non-paved areas, or flush with grade in paved areas (to keep water away from covers). There should be smooth transition between concrete envelope and surrounding grade. Allowances must be made for spacer rings or pavement rings where used.]

_____3. Are transformer base cover gaskets properly installed, with all bolts properly torqued? [Use only stainless steel bolts; do not reuse shipping bolts unless so intended by the manufacturer.]

Lights

_____4. Are all equipment and materials new, and as specified? Are lamps and isolation transformers of proper wattage? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53.]

_____5. Are all light locations in accordance with the plans?

_____6. Are the correct filters installed for runway and taxiway edge lights, and light lenses properly oriented for threshold/end? If taxiway lights use masked lamps, are masked lamps properly oriented?

_____7. Are the light fixtures the proper distance from the pavement or defined edge, in a straight line and within tolerance?

_____8. Is the height of light fixtures in accordance with the plans, and frangible couplings properly installed?

_____9. Are all light fixtures plumb and level, with hardware tightened?

Cables

_____10. Are L-823 connectors of proper size for the cable, and are field attached connectors applied properly per details including using terminal crimping tool, cable stripping tool, and heat shrink?

_____11. Are all L-823 Type II two-conductor secondary connectors Class A (factory molded)?

_____12. Is light base properly grounded? Are ground rods installed to minimum depth below grade and within maximum spacing?

_____13. Is counterpoise properly separated from light bases and base grounding provisions?
[The counterpoise/grounding policy may not be the same at each air base. Ensure compliance with plans.]

System

_____14. Are lights labeled in accordance with approved numbering scheme, with proper tag and size of numerals? Are edge light numbering tags facing the pavements?

_____15. Are all new lights operational? Is there any visual evidence of dimming?

_____16. Have installed fixtures passed photometric testing standards?

Table 4. Checklist for Lighted Guidance Signs

Materials

____1. Is all equipment and material new? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53.]
____2. Are L-823 connectors of proper size and do they properly fit the cable? Are they Type II two-conductor secondary connectors Class A (factory molded)?
____3. Are transformer housings of the correct type, size and material?
____4. Are signs of required size per plans and specifications?
____5. Do signs have the correct wind load rating per contract requirements?

Installation

____6. Are all sign locations in accordance with the plans? [Proper distance from pavement or intersections and collocation with marking.]
____7. Is the correct sign at the proper location? [Correct message face(s), proper orientation with respect to traffic surfaces.]
____8. Is the numbering of signs (sign ID), size of numerals, and method of numbering in accordance with the plans and specifications?
____9. Are the sign foundations according to plans and specifications? Are tethers installed?
____10. Has taping/heat shrink for field attached connectors been applied properly, per details?
____11. Are tops of signs horizontal and are the sign mounts tight?
____12. Does the height of breakable couplings not exceed the allowable maximum?
____13. Are the signs connected to the proper circuit as shown on plans?
____14. Is the plug disconnect for the sign properly installed?
____15. Are sign and transformer base properly grounding in accordance with the plans, with correct size ground rods installed to a least minimum depth below grade?
____16. Is counterpoise properly separated from sign and sign transformer base grounding provisions?
____17. Are transformer base cover gaskets properly installed, with all bolts properly torqued?
[Use only stainless steel bolts; do not reuse shipping bolts unless so intended by the manufacturer.]
____18. Are all new signs operational?
____19. Has contractor supplied all necessary maintenance and repair manuals, operating instruction books, and spare parts list? [If spares required, check for correct quantity and type.]
____20. Have the installed signs passed photometric testing standards?

Table 5. Checklist for REIL

_____1. Is all equipment and material new? [Items covered by the FAA L-800 Type number series should be listed in the FAA AC 150/5345-53.]
_____2. Are the isolation/interface transformers, if required, of the proper type and capacity as required by the specifications, or as recommended by the REIL manufacturer?
_____3. Are the location of the light units according to plans?
_____4. Is the elevation of the flash heads and associated equipment in accordance with the plans?
_____5. Are the foundations and equipment mountings according to plans, and do breakable couplings not exceed allowable height?
_____6. Is the horizontal and vertical aiming correct?
_____7. Where transformer bases are used to house isolation/interface transformers, are tops of these slightly above surrounding grade to keep water away from the covers? Is there a smooth transition between concrete envelopes of these bases and the surrounding grade?
_____8. Are all L-823 Type II two-conductor secondary connectors Class A (factory molded)?
_____9. Are the base cover gaskets properly installed and the cover properly bolted with stainless steel bolts?
_____10. If connection into series circuit is specified, are the L-823 connectors of proper size and do they properly fit the cable?
_____11. Has taping/heat shrink for field attached connectors been applied properly, per details?
_____12. Has grounding of REIL units, and transformer base if used, been provided in accordance with the plans? Are ground rods installed to a least minimum depth below grade?
_____13. Is counterpoise properly separated from REIL units and transformer base grounding provisions?
_____14. Are equipment enclosures weathertight?
_____15. Are all conductor (power and control) connections tight?
_____16. Are the voltages (power and control) within manufacturer specified limits? In case of regulator feed to REIL, are these voltages within limits at all the brightness steps at which the REIL operate?
_____17. Is the operation of the REIL in accordance with the airfield operations and specifications?
[Control, rate of flashing, synchronization of slave and master units]
_____18. Has contractor supplied all necessary maintenance and repair manuals, operating instruction books, and spare parts list? If required, have spare parts such as lamps been provided?
_____19. Have the installed fixtures passed photometric testing standards?

Table 6. Checklist for PAPI (1 of 2)

____1. Is all equipment and material new? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53.]

____2. Is the location of PAPI light boxes according to plans? [Distance from threshold, distance from runway edge, distance between light boxes.]

____3. Are the foundations and equipment mountings according to plans, and do breakable couplings not exceed allowable height?

____4. Is the positioning and aiming of the light units in a light bar in accordance with requirements?

- ____ a. LONGITUDINALLY: In line perpendicular to the runway centerline within ±6 inches.
- ____ b. ELEVATION: In a horizontal plane within a tolerance of ±1 inch (25 mm), and the centers of the optical aperture of the light units within ±1 foot (300 mm) of the runway crown.
- ____ c. AZIMUTH: Parallel to the runway centerline within a tolerance of ±½ degree.
- ____ d. VERTICAL AIMING: Within ±2 minutes of the specified angle for each light unit.
  [Aiming angles should be stenciled on each light box.]

____5. Is the aiming device and the optical bench properly calibrated and operational? Are the optical systems, if required, properly focused?

____6. PHOTOCELL: Is the photocell properly aligned? Does it change the brightness of the lamps? Is the time-delay (45-75 seconds) in the photocell operational?

____7. Does the tilt switch in each light unit operate when the unit is tilted down between ¼ - ½ degree, and also when tilted upward between ½ - 1 degree?

____8. Does the lamp bypass, if included, operate with each bulb when the bulb is disconnected?

____9. Is the current in the lamps within the limit for the high and low brightness?

____10. Are the lamps of proper wattage? Is the selected low brightness correct for local conditions?

____11. Is the voltage at the adapter unit with the facility at full brightness within the specified voltage limits?

____12. Does the megohmmeter test indicate satisfactory cable insulation resistance?

____13. If the aiming device is supplied as part of the contract, has a carrying case for the aiming device been provided?

____14. In case of adapter-fed PAPI, are the connectors at the breakable couplings of the correct type?

____15. When regulator feed PAPI system is installed, are isolation transformer connections to the lamp housings made by using L-823, Style 1 or 6 connectors meeting FAA AC 150/5345-26?

Table 6. Checklist for PAPI (Cont., 2 of 2)

____16. Are the isolation transformers, if required, of the proper type and capacity as required by specification, or as recommended by the PAPI manufacturer?
____17. Are the transformer housings/hand holes, if required, of the correct type, size, and materials?
____18. Where transformer bases are used to house the power adapter, are tops of these slightly above surrounding grade to keep water away from the covers? Is there a smooth transition between concrete envelopes of these bases and the surrounding grade?
____19. If connection into series circuit is specified, are the L-823 connectors of proper size and do they properly fit the cable?
____20. Has taping/heat shrink for field attached connectors been applied properly, per details?
____21. Has grounding of PAPI units, and transformer bases if used, been provided in accordance with the plans? With ground rods installed to at least minimum depth below grade?
____22. Is counterpoise properly separated from PAPI units and transformer base grounding provisions?
____23. Are equipment enclosures weathertight?
____24. Are all conductor (power and control) connections tight?
____25. Has contractor supplied all necessary maintenance and repair manuals, operating instruction books, and spare parts list? If required, have spare parts such as lamps been provided?
____26. Have the installed fixtures passed photometric testing standards?

Table 7. Checklist for Underground Cable, Duct and Manholes/Handholes (1 of 2)

Progress Inspection

_____1. Is underground cable the correct type (L-824 Type C for series lighting circuits), and correct size?
[Cable should be marked to show manufacturer or trade mark or catalog number, conductor size, voltage rating, and type.]

_____2. Are conduit and fittings products as required by plans and specifications and applicable standards?
[Size, type, compliance with applicable standards such as UL or Federal Specifications.]

_____3. Are ends of cable taped when cable is on reels, beside the trench or duct bank, in a light base, manhole or hand hole, while awaiting connection to an isolation transformer?

_____4. Are the L-823 connectors of proper size and do they properly fit the cable?

_____5. Has taping/heat shrink for field attached connectors been applied properly, per details?

_____6. Is cable installed without kinks or sharp bends, and without splices in the ducts between light bases or manholes/hand holes?

_____7. Is trenching done using proper equipment? [Road patrols and graders are not to be used for trenching.]

_____8. Is the counterpoise wire installed as specified and securely attached to ground rods?
[Counterpoise should not be connected to light bases or grounding provisions for manholes and hand holes.]

_____9. Do ground rods meet specified requirements and are they installed at required locations?

_____10. Is the depth, elevation, and slope of underground duct in accordance with plans and specifications, and are the size and number of ducts correct?

_____11. Are ducts being cleaned properly?

_____12. Are the ends of spare ducts being plugged in manholes, hand holes, and boxes at building entrances? Are stubouts being capped?

_____13. Is there sufficient cable slack installed at each light and hand hole?

Final Inspection

_____1. Does the new underground cable, where connected into the existing lighting circuit, meet the minimum insulation resistance requirements?

_____2. Are high voltage and low voltage cables properly separated in handholes and manholes, and in separate duct, in accordance with the plans and specifications?

_____3. Are the cables identified in all handholes, manholes and wireways?

_____4. Are cables in manholes mounted on non-metallic racks and properly secured? Are cables neatly organized and secured in handholes if racks are not used?

Table 7. Checklist for Underground Cable, Duct and Manholes/Handholes (Cont., 2 of 2)

____5. Are cable racks and manhole/hand hole frame and covers properly grounded?

____6. Do ducts terminating in manholes and hand holes have end bells, and is duct penetration properly grouted, plugged or sealed?

____7. Has backfilling and compaction been properly done (no trench settlement), and are disturbed areas properly restored?

____8. Are cable or duct markers installed at each change of direction, every 200 feet (60 m) along straight run with no access structure, and at ends of all duct that are not terminated at hand holes or manholes?

____9. Are cable and duct markers correctly and neatly inscribed?

____10. Is sufficient cable slack provided at each primary connector termination?

____11. Does the cable insulation meet the minimum resistance requirements?

<u>Air Mobility Command (AMC) Preferences</u>

____1. Does each manhole/hand hole have the wheel load rating cast in the concrete top and access lid assembly.

____2. Does each manhole/hand hole have the year of installation cast in the concrete top or the metal hatch.

____3. Does each manhole/hand hole used for airfield lighting circuits have the words “Airfield Lighting” cast in the top of the metal hatch.

____4. Are manholes/hand hole exteriors coated with a water sealant on the bottom and all sides?

____5. Are all conduits filled with cable(s) sealed around the cable with duct seal? [Unless directed otherwise by the base engineer.]

____6. Does the ground rod in manholes/hand holes stub up a minimum of 6 inches above the floor with a ground lug attached for ground connections?

____7. Are ground connections made to all metal equipment in the manhole/hand hole using number 4 bare solid copper conductor?

____8. Is the soil grade around the manholes/hand holes one half inch below the top of the manhole/hand hole and sloped one quarter inch per foot (6 mm per 300 mm) away for 15 feet (4.5 m)?

____9. Are underground conduits concrete encased on circuits over 600 volts? [Use red dye in the concrete to indicate an electrical duct bank.]

____10. Are all airfield lighting series circuit in their own individual 2 inch (53 mm) conduit?

____11. Have all cables been tested in accordance with this technical paper?

Table 8. Checklist for Vault (1 of 3)

Equipment

_____1. Is installed equipment and material new? [Items covered by the FAA L-800 series should be listed in the FAA AC 150/5345-53. Furnished equipment and material other than that covered by the FAA L-800 series must be in accordance with the requirements of all applicable contract plans, specifications, standards (such as UL), and approved shop drawings with regard to quality, quantity, capacity, size, and type.]

_____2. Have shop drawings for all major equipment items (switches, power panels, cutouts, etc.) been submitted by the contractor and approved by the engineer?

_____3. Are all switches, panels, breakers, contactors, and relays installed in proper enclosures, and are panels and switches pull/junction boxes of the correct type and size and easily accessible?

_____4. Does specially made equipment, such as relay/contactor/interface panels, or terminal block cabinets, meet applicable specifications?

_____5. Is the wall mounted equipment properly and securely mounted, and is the floor mounted equipment sufficiently raised above the floor?

_____6. Are the covers of electrical equipment identified as to function, voltage and phase?

_____7. Is labeling/stenciling of proper color, size and material? Are high voltage warning signs installed where required?

_____8. Have no equipment cabinets been used as pull/junction boxes?

_____9. Have all necessary maintenance and repair manuals, operating instruction books, and spare parts lists been supplied by the contractor?

_____10. Is there sufficient space for operation of high voltage (HV) disconnects, and are all HV disconnects properly protected against accidental contact with the human body?

_____11. Does no switch interrupt neutral?

_____12. Are all breakers of correct size and all switches fused correctly to protect the connected conductors? Are spare fuses furnished (if required)?

_____13. Are the phases sufficiently balanced?

_____14. Is a series circuit cutout installed for each CCR powered lighting circuit?

_____15. If oil-type, is the oil level acceptable in L-828/9 regulators and oil-filled transformers?

_____16. Where radio control of field lighting is provided, is the control unit functioning properly and in accordance with the plan of operation?

_____17. Is the location, mounting and wiring of the L-854 radio control equipment and it’s antenna in accordance with the plans and specifications?

_____18. Are the lightning arresters vertically mounted, of correct rating and properly connected?

_____19. Are framed wiring and schematic diagrams, if required, provided in the vault?

Table 8. Checklist for Vault (Cont., 2 of 3)

Duct/Conduit

_____1. Are all conduits of the type specified?
_____2. Are all conduit sizes in accordance with the NEC, and are proper bushings installed at conduit terminations?
_____3. Are all bends made in accordance with the NEC, and is the number of bends in one conduit run within allowable limits?
_____4. Are all steel conduit galvanized?
_____5. Are all conduit entering the vault from outdoor duct sealed?
_____6. Are all exterior conduit made rain-tight?
_____7. Are all conduit cover plates installed and open knock-out holes in boxes/panels covered?
_____8. Are all empty conduits that do not terminate at equipment or junction boxes properly capped?
_____9. Are the square duct of the correct type and size and with covers hinged at the bottom?

Wiring

_____1. Is the power and control wiring in accordance with applicable diagrams?
_____2. Are all circuits continuous and free from shorts and unspecified grounds?
_____3. Are the power and control conductor types and sizes as specified, and are all conductors of proper voltage rating?
_____4. Where wire sizes are not specified, are they of sufficient ampacity to carry the presently connected and future loads?
_____5. Are the power and control wiring connections to terminals tight, and are the terminal lugs of proper size for conductors and connected?
_____6. Are the wires laced together and does the finished work present a neat and professional appearance?
_____7. Do all wire terminations have enough slack to permit natural movement due to temperature changes and magnetic forces?
_____8. Are all conductors properly identified?
_____9. Are the branch circuits color coded in accordance with applicable specifications?
_____10. Is the number of wires in conduit and junction boxes within the allowable limits of the NEC?
_____11. Are HV and LV cables properly separated in accordance with the NEC?

Table 8. Checklist for Vault (Cont., 3 of 3)

Grounding

_____ 1. Are the tops of ground rods at the required depth below grade?
_____ 2. Are all the ground rods serving the vault tied together by the use of bare copper wire?
_____ 3. Is the grounding wire size in accordance with the plans and/or the NEC?
_____ 4. Is the grounding wire protected in accordance with plans and/or the NEC?
_____ 5. Are all metallic pull boxes, raceways, cabinets, cable armor, transformer enclosures, and cages properly grounded, and are the grounding wires connected to the metal surfaces with proper lugs and connectors? [Metal surface must be cleaned of paint and grease where the ground connections are made.]
_____ 6. Is the power neutral grounded only at the power service entrance?
_____ 7. Are the neutrals of the secondary distribution systems properly grounded?

Tests

_____ 1. Does the cable of each series and parallel lighting circuit meet the minimum insulation resistance requirements?
_____ 2. Is the supply voltage to regulators within acceptable limits?
_____ 3. Are the output current values of each regulator at each intensity step within allowable limits?
_____ 4. Is the open circuit protective device of each regulator functioning properly?
_____ 5. Has each control been operated the required number of times and are they functioning properly, at each control location?
_____ 6. Has each lighting circuit been operated at each brightness step for the required number of hours and are they functioning properly?
_____ 7. Is the ground resistance equal or less than the specified value? [Measure with vault neutral disconnected from power company's neutral.]
_____ 8. Is photocell, if required, operating properly?
_____ 9. Is the entire lighting system functioning in accordance with the approved plan of operation?

At Final Inspection

_____ 1. Does new underground cable meet the minimum insulation resistance requirements?
_____ 2. Are high voltage and low voltage cables properly separated in hand holes and manholes, and in separate duct, in accordance with the plans and specifications?
_____ 3. Are the cables identified in all hand holes, manholes and wireways?
_____ 4. Are cables in manholes mounted on non-metallic racks and properly secured? Are cables neatly organized and secured in hand holes if racks are not used?
_____ 5. Are cable racks and manhole/hand hole frame and covers properly grounded?
_____ 6. Do ducts terminating in manholes and hand holes have end bells, and is duct penetration properly grouted, plugged or sealed?
_____ 7. Has backfilling and compaction been properly done (no trench settlement), and are disturbed areas properly restored?
_____ 8. Is sufficient cable slack provided at each primary connector termination?
_____ 9. Does the cable insulation meet the minimum resistance requirements?

1.3 CABLE, CONNECTOR, AND ISOLATION TRANSFORMER INSPECTION.

The primary and secondary cable leads of the transformers are supplied with factory-installed molded connectors. Visual inspection of these items during installation is very important. Minor cuts, bruises, or mishandling may result in a progressive deterioration that will eventually cause complete failure, but not until sometime after acceptance tests. During installation, the following items must be inspected (see also checklist Table 7).

1.3.1 Connectors.

The mating surfaces of molded connectors are to be clean and dry when plugged together. If clean and dry inside, these high voltage connectors, with taping, form a connection equal or superior to a conventional high voltage splice. Conversely, if they are wet or dirty inside, taping will not produce a satisfactory connection. Two or three turns of tape, or heat shrink tubing, should be used to hold the connector together and keep the parting line clean. Cleanliness of mating surfaces can be ensured by keeping the factory-installed caps in place until the final connection is made. The mating surfaces of uncapped connectors should not be laid down, touched, or breathed upon. If a connection must be broken the connectors should be immediately capped.

1.3.1.1 The connectors are to be completely plugged together. After initial plugging, trapped air pressure may partially separate the plug and receptacle. If this happens, wait a few seconds and push them together again. Two or three turns of tape should be used to hold them in place.

1.3.2 Cables.

1.3.2.1 The cables are not to be cut by shovels, nicked, crushed by vehicle wheels, bruised by rocks, or damaged in any way during handling and installation.

1.3.2.2 The cables are to be buried to the specified depth below finished grade, and all other detailed requirements of the installation specification must be met.

1.3.2.3 The cables should not directly cross each other and must be separated by the specified distance.

1.3.2.4 Screened material should be placed under and over the cables, and rocks or pebbles should not contact the cables.

1.3.2.5 The cables are not to be bent sharply where they enter (or leave) a conduit, and should be supported properly by tamped ground so future settling will not cause sharp bends.

1.4 CABLE ELECTRICAL TESTS.

Test cables directly buried in earth (that is, not in duct or conduit) before and after the trench is back-filled. Test each underground circuit as follows:

1.4.1 Continuity ohmmeter or equivalent continuity test on each series circuit. The circuit should then be checked with a megohmmeter test set to make sure it is free of grounds. Any faults indicated by these tests should be located and repaired before proceeding with high voltage tests.

1.4.2 High voltage insulation resistance test on each series and multiple underground circuit to determine complete freedom from grounds. Whenever possible, these tests must be performed when the ground is thoroughly wet because circuit wiring that passes insulation resistance tests during dry weather may fail after a heavy rain.

1.4.2.1 The test procedure is as follows for each circuit:

1 Disconnect both leads from the regulator output terminals. Support both leads so there are air gaps of several inches between bare conductors and ground. Make sure the cable sheath is clean and dry for a distance of at least 1 foot (300 mm) from the end of the cable. Also make sure exposed insulation at the end of the cable is clean and dry.

2 Test each circuit immediately after installation according to “First Test on New Circuit.” Test any circuit installed for 60 days or more, even if it has not been operated, according to “Succeeding Old Circuit.” (See Table 9.)

3 The maximum acceptable leakage current, in microamperes, should not exceed the values in paragraph 1.4.2.4.

4 When additions are made to old circuits, test only the new sections according to “First Test on New Circuits.” Test the complete circuit at the reduced voltages to ensure reliable operation. See Table 9.

5 Connect both conductors, and apply the test voltage shown for 10 minutes between conductors and ground.

Table 9. Cable/Circuit Test Procedures

	First Test on New Circuit	Succeeding Old Circuit
Complete Approach System (5,000V leads, 500 and 300W transformers)	9000V	5000V
Touchdown Zone and Center-line Light Circuits (5,000V leads, 200W transformers)	9000V	5000V
High Intensity Runway Edge Light Circuits, (5,000V leads, 500 and 200W transformers)	9000V	5000V
Medium Intensity Runway and Taxiway Circuits (5,000V leads and 30/45W transformers)	6000V	3000V
600 Volt Circuits	900V	600V

1.4.2.2 The above tests must be performed with a suitable high voltage DC tester that has a steady, filtered output voltage. The high voltage tester must have an accurate voltmeter and microammeter for reading the voltage applied to the circuit and the insulation leakage current.

1.4.2.3 All high voltage tests on airfield lighting circuits must be carefully supervised by qualified government personnel to ensure that excessive voltages are not applied to circuits.

1.4.2.4 During the last minute of the above tests, the insulation leakage current in microamperes for each complete circuit must not exceed the following value calculated for each circuit:

- Allow 2 microamperes for each 30/45, 100, 200, 300 and 500W series transformer tested at voltage shown in Table 9.
- Allow one microamperes for each 300 feet (90 m) of cable tested at voltage shown in Table 9. This value includes allowances for the normal number of connectors and splices.
- Using a 1000 volt DC crank-type megohmmeter, each circuit must measure above 30 megohms to be satisfactory.

1.4.2.5 If the leakage current exceeds the value calculated as outlined above, the circuit must be sectionalized and the above test repeated for each section. Defective components must be located and repaired or replaced until the entire circuit passes the test.

1.4.2.6 Ensure the test voltage specified in paragraph 1.4.2.1 is applied to a circuit in the final acceptance test. Adjust the voltage so the voltmeter reads the desired value before the leakage current is read. If there is a difficulty in obtaining the desired voltage, obtain a second test set and validate the reading. Correct as necessary. Maintain a log book of the circuit readings and pass this on to the maintenance section for airfield lighting.

1.4.2.7 On new circuits, perform a megohmmeter test check immediately after the circuit has passed the high voltage tests. This megohmmeter reading then can be used by maintenance personnel for a comparison with further readings to determine the circuit conditions. Record ambient temperature and weather conditions at the time of test.

1.5 CONSTANT CURRENT REGULATOR INSPECTION.

Each constant current regulator must be inspected to ensure that porcelain bushings are not cracked, no shipping damage has occurred, connections are correct, switches and relays operate freely and are not tied or blocked, fuses (if required) are correct, and the oil level of oil-filled regulators is correct. Only relay panel covers must be removed for this inspection; the main tank of oil-filled regulators need not be opened. Information on the regulator instruction plate must be followed. All covers must be cleaned and tightly replaced after inspection and tests are completed (See also checklist for vault Table 8).

1.6 REGULATOR ELECTRICAL TESTS.

The supply voltage and input tap must be checked to see that they correspond:

1.6.1 With the load disconnected, energize the regulator once and see if the open-circuit protector de-energizes the regulator within 3 seconds.

1.6.1.1 Connect the load circuit (after it has been tested for opens and grounds as specified in paragraph 1.4 and inspected to ensure all fixtures are properly lamped).

1.6.1.2 Using only an ammeter, calibrated with an accuracy of ±3 percent, measure input voltage and output current simultaneously at the highest brightness step. Note that when measuring output voltage, the accuracy can be less since the potential transformer to be used will have some built-in tolerance. Following are suggestions to ensure successful measurements:

1.6.1.2.1 Use proper equipment. Laboratory quality instrumentation generally give readings within ±1 percent accuracy, while standard grade multimeters, potential transformers, and current transformers may have more than 5 percent error.

Suggest using power analyzers with a scaling feature allowing for internal conversion of current transformer and power transformer ratios, eliminating need to multiply in power transformer and current transformer ratios. The phase relationship between the power transformer and current transformer secondary windings will affect the reading if not connected properly (in phase) to the power analyzer, and watts and volt-amperes (VA) will fluctuate or indicate low. If this occurs, simply swap polarity on either power transformer or current transformer secondary at the connection to the power analyzer.

1.6.1.2.2 Energize the load at least 5 minutes before taking readings, to ensure accuracy.

1.6.1.2.3 Use the lowest ratio possible on the current transformer without over-ranging the current input on the power analyzer. Never connect the airfield load directly to the power analyzer; output voltages on constant current regulators (CCRs) can exceed 4,500V.

1.6.1.2.4 If REIL lights are connected to the series lighting circuit, this will cause fluctuation in the VA and watt readings. Manually shut off the REIL lights before taking readings, then add REIL load. Note that REIL systems require spare capacity in the CCR to operate properly. Consult the REIL manual for power requirements.

1.6.1.2.5 Measurements will vary with soil and weather conditions. The best days for taking readings are when the ground is wet.

1.6.1.3 Use a recording voltmeter or take readings during both day and night at intervals of one hour to obtain an average supply voltage.

1.6.1.4 If the regulator has input voltage taps, select the tap which most nearly corresponds to the average supply voltage. Ensure the output current on each brightness tap is within the current limits of FAA AC 150/5345-10 after any necessary supply voltage correction is made.

1.6.2 In some current regulators with input voltage taps, the output current will vary in proportion to input voltage changes. In all cases the output current values must be within the current limits of FAA AC 150/5345-10.

1.6.3 For regulators which have automatic supply voltage correction instead of input taps, the output current must be within the current limits of FAA AC 150/5345-10.

1.6.4 The following tests are not mandatory, but will help locate the trouble if the above test indicates improper operation:

- De-energize and lock out regulator, disconnect the load, short-circuit the output terminals with jumper, re-energize regulator observing all safety precautions, and measure the output current with clamp-on ammeter. If measured values are equal to nameplate values and within the current limits of FAA AC 150/5345-10, the regulator is operating satisfactorily. Check the load circuit for faults.

- Connect load cables (after the circuit has been tested for opens and grounds, as specified in paragraph 1.4, and inspected to ensure all fixtures are properly lamped) and measure output current and output voltage simultaneously with the regulator operating on the highest brightness tap. The significance of the readings is as follows:

- Satisfactory operation is indicated by correct output current and an output voltage which is slightly higher than the estimated load voltage and does not exceed the rated output voltage. The measurement of the load voltage must be compared with the design load voltage calculated by the design engineer. An example of this calculation is shown in UFC 3-535-01 Figure 13-4.

- A correct output current, with an output voltage appreciably less than the estimated load voltage, indicates complete or partial shorting of the load.

- A correct output current, with an output voltage exceeding the rated load output voltage, indicates an overload.

- A reduced output current, with an output voltage exceeding the rated load output voltage, indicates an overload, possibly caused by a poor connection in the load circuit. De-energize the regulator as soon as safely possible, to prevent damage.

- A reduced output current, with an output voltage not exceeding the rated output voltage, indicates a faulty regulator or reduced supply voltage.

- A zero output current, with excessive output voltage, indicates an open in the load circuit and failure of the open-circuit protector in the regulator. De-energize the regulator as soon as safely possible, to prevent serious damage.

1.7 LIGHTING FIXTURE INSPECTION.

An inspection must be made to determine that the color, quantity, and locations of lights meets the installation drawings. Each light must be inspected to determine that it operates, is properly leveled and aimed, glass is not broken or cracked, and correct lamps are installed, all according to the technical orders and manufacturer’s instructions. (See also checklists for lights, signs, and other visual aids, Table 1, Table 2, Table 3, Table 4, Table 5, and Table 6.)

1.8 SYSTEM MISCELLANEOUS COMPONENTS INSPECTION.

Components such as control panels, relay cabinets, or panel boards, must be visually inspected for damage, correct connections, proper fuse and circuit breaker ratings, and compliance with the installation drawings. (See also checklist for vault, Table 8.)

1.9 SYSTEM OPERATION.

After components and circuits have been inspected and tested, as specified in the preceding paragraphs, the entire system must be tested as follows:

1.9.1 Procedures.

1.9.1.1 Operate each switch of the airport lighting and taxiway panel in the control tower so each switch position is reached at least twice. During this process, observe all lights and vault equipment to determine that each switch properly controls the corresponding circuit.

1.9.1.2 Repeat the above test for the panel in the alternate control station (vault) and then repeat it again, using the local control switches on the regulators.

1.9.1.3 Operate each lighting circuit continuously at highest brightness step for 15 minutes maximum, and continuously at least 3 hours at middle intensity. Make a visual inspection at the beginning and end of this test to determine that the correct number of lights are operating at full brightness. Dimming of some or all of the lights in a circuit is an indication of grounded cables. In addition, measure the lamp terminal voltage on at least one light in each multiple circuit to determine that it is within ±1 percent of the rated lamp voltage marked on each lamp.

1.10 ADDITIONAL GUIDANCE.

Additional guidance on acceptance testing is in the FAA Advisory Circulars listed in Chapter 12 and Chapter 13.