



U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: PRECISION APPROACH PATH
INDICATOR (PAPI) SYSTEMS

Date: 4/12/05
Initiated by: AAS-100

AC No.: 150/5345-28F
Change:

1. **PURPOSE.** This Advisory Circular (AC) contains the Federal Aviation Administration (FAA) standards for the Precision Approach Path Indicator (PAPI) systems, which provides pilots with visual glideslope guidance during approach for landing.
2. **EFFECTIVE DATE.** Effective six months after the issue date of this AC, only that equipment qualified in accordance with the specifications herein will be listed in accordance with AC 150/5345-53, *Airport Lighting Equipment Certification Program*.
3. **CANCELLATION.** AC 150/5345-28E, *Precision Approach Path Indicator (PAPI) Systems*, dated May 25, 2004, is cancelled.
4. **APPLICATION.** The specifications contained in this AC are recommended by the FAA in all applications involving development of this nature. For airport projects receiving Federal funds under the airport grant assistance or the passenger facility charge programs, the use of these specifications is mandatory.
5. **PRINCIPAL CHANGES.** The following principal changes are incorporated:
 - a. The stated requirement for de-energizing the PAPI due to an excessive inadvertent light unit tilt angle. The existing requirement tilt angle in both the up and down directions is too restrictive for the certification of existing and new equipment.
 - b. The stated requirement for equipment surge and transient protection. Additional detail is added to clarify the test waveform duration/amplitude and location category per FAA Engineering Brief #67, dated November 2004.
 - c. The stated testing requirement for equipment transient protection is changed to agree with paragraph 3.14.1.
6. **METRIC UNITS.** To promote an orderly transition to metric units, this specification includes both "English" and "Metric" dimensions. The metric conversions may not be exact equivalents and until there is an official changeover to the metric system the English dimensions will govern.

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Director of Airport Safety and Standards

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1. SCOPE

This AC contains the equipment requirements for PAPI systems.

NOTE: *Chapter 2, Section 16, Siting and Installation Standards have been removed from this document and relocated to AC 150/5340-30, Installation Details for Airport Visual Aids.*

1.1 PAPI Equipment Classifications

- a. Type.
 - (1) L-880 - System consisting of 4 light units.
 - (2) L-881 - System consisting of 2 light units.
- b. Style.
 - (1) Style A - Voltage powered (multiple circuit) systems.
 - (2) Style B - Current powered (series lighting circuit) systems.
- c. Class.
 - (1) Class I - Systems that operate from -31 degrees Fahrenheit (F) (-35 degrees Centigrade [C]) to 131 degrees F (55 degrees C).
 - (2) Class II - Systems that operate from -67 degrees F (-55 degrees C) to 131 degrees F (55 degrees C).
- d. Options.
 - (1) Lamp socket bypass device in paragraph 3.11.2.
 - (2) An isolation transformer consolidating harness for Style B systems in paragraph 3.9.6.3.1.

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2. APPLICABLE DOCUMENTS

The following documents are referenced in this AC.

a. FAA ACs:

- AC 150/5345-53 Airport Lighting Equipment Certification Program
- AC 150/5345-26 Specification for L-823 Plug and Receptacle, Cable Connectors
- AC 150/5345-47 Isolation Transformers for Airport Lighting Systems
- AC 150/5345-49 Specification L-854, Radio Control Equipment

b. FAA Standards and Drawings:

- FAA-STD-019 *Lightning and Surge Protection, Grounding, Bonding and Shielding Requirements for Facilities and Electronic Equipment*
- FAA Drawing C-6046 *Frangible Coupling, Type 1 and 1A, Details*

Electronic copies of FAA ACs may be obtained from:

Internet: <http://www2.faa.gov/arp/150acs.cfm>

or by standard mail from:

Department of Transportation
General Services Paragraph M443.2
Washington, DC 20590

Electronic copies of FAA Standards may be obtained from:

Internet: <http://204.108.10.116/nasiHTML/FAAStandards/>

FAA drawings may be obtained from:

FAA William J. Hughes Technical Center
NAS Documentation Facility, ACK-1
Atlantic City International Airport
New Jersey, 08405

c. Military Specifications and Standards.

- MIL-C-7989 *Covers, Light Transmitting, for Aeronautical Lights, General Specification for*
- MIL-STD-810F *1 January 2000, Environmental Test Methods and Engineering Guidelines*

d. Federal Standards

FED-STD-595 *Colors Used in Government Procurement*

Copies of Military Standards may be obtained from:

Internet: <http://www.dodssp.daps.mil/> (fees for documents)

or compact discs (CDs) on website order form by standard mail from:

DAPS / DODSSP
Building 4 / Section D
700 Robbins Avenue
Philadelphia PA 19111-5094

Copies of Federal Standards may be obtained from:

Internet: <http://global.ihs.com>
or telephone: 800-854-7179

- LM-35 e. Illuminating Engineering Society (IES) Transaction.
IES Approved Method for Photometric Testing of Floodlights Using Incandescent or Discharge Lamps

Copies of IES standards may be obtained from:

Internet: <http://www.iesna.org/> (fees for documents)

or by standard mail from:

Illuminating Engineering Society
120 Wall Street
17th Floor
New York, New York 10002

f. Society of Automotive Engineers (SAE)

AS-25050 *Colors, Aeronautical Lights and Lighting Equipment, General Requirements for*

Copies of SAE Standards are available from:

Internet: <http://www.sae.org>

or by standard mail at:

SAE World Headquarters
400 Commonwealth Drive
Warrendale, PA 15096-0001 USA

g. Institute of Electrical and Electronics Engineers (IEEE)

C62.41-1991 *IEEE Recommended Practice on Surge Voltages in Low-Voltage AC Power Circuits.*

Copies of IEEE Standards are available from:

Internet: <http://www.sae.org>

or by standard mail at:

IEEE Customer Service
445 Hoes Lane
PO Box 1331
Piscataway, NJ 08855-1331

FAX: +1 732 981.9667
Email: onlineproducts@ieee.org

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3. REQUIREMENTS

A PAPI system consists of:

- a. Four identical light units, Type L-880, or two identical light units, Type L-881.
- b. A power and control unit (PCU) (for style A systems only).
- c. Aiming and calibration equipment (may be part of the light units).

3.1 Environmental

The PAPI equipment must be designed for outdoor installation and continuous operation in the following environmental conditions:

3.2 Temperature

The PAPI equipment must operate in the following ambient temperatures:

- a. Class I systems - from -31 degrees F (-35 degrees C) to 131 degrees F (55 degrees C).
- b. Class II systems - from -67 degrees F (-55 degrees C) to 131 degrees F (55 degrees C).

3.3 Humidity

The PAPI equipment must operate in any relative humidity up to 100 percent.

3.4 Sand and Dust

The PAPI equipment must operate when exposed to windborne sand and dust particles.

3.5 Wind-blown Rain

The PAPI equipment must operate when exposed to wind-blown rain from any direction.

3.6 Wind

The PAPI equipment must operate when exposed to wind speeds up to 100 miles per hour (mph) (161 kilometers per hour [km/hr]) from any direction.

3.7 Salt Spray

The PAPI equipment must operate when exposed to a salt laden atmosphere with relative humidity up to 100 percent.

3.8 Sunshine

The PAPI equipment must operate when exposed to solar radiation with ambient temperatures stated in paragraph 4.1, Temperature.

3.9 Light Units

3.9.1 Photometric Requirements

- a. Each light unit must have at least two lamps.
- b. The light units must produce a beam of light split horizontally, with white light in the top sector and red light in the bottom.
- c. When the PAPI is viewed at 1000 feet (300 meters), the transition from red light to white light must be within 3 minutes of arc at the beam center and within 5 minutes of arc at the beam edges.
- d. A line drawn through center of the transition band at +10 degrees, 0 degrees, and -10 degrees must be straight within 3 minutes of arc.
- e. The transition band must be flat within 3 minutes of arc.
- f. The light distribution and intensity for each light unit must be per Figure 1.

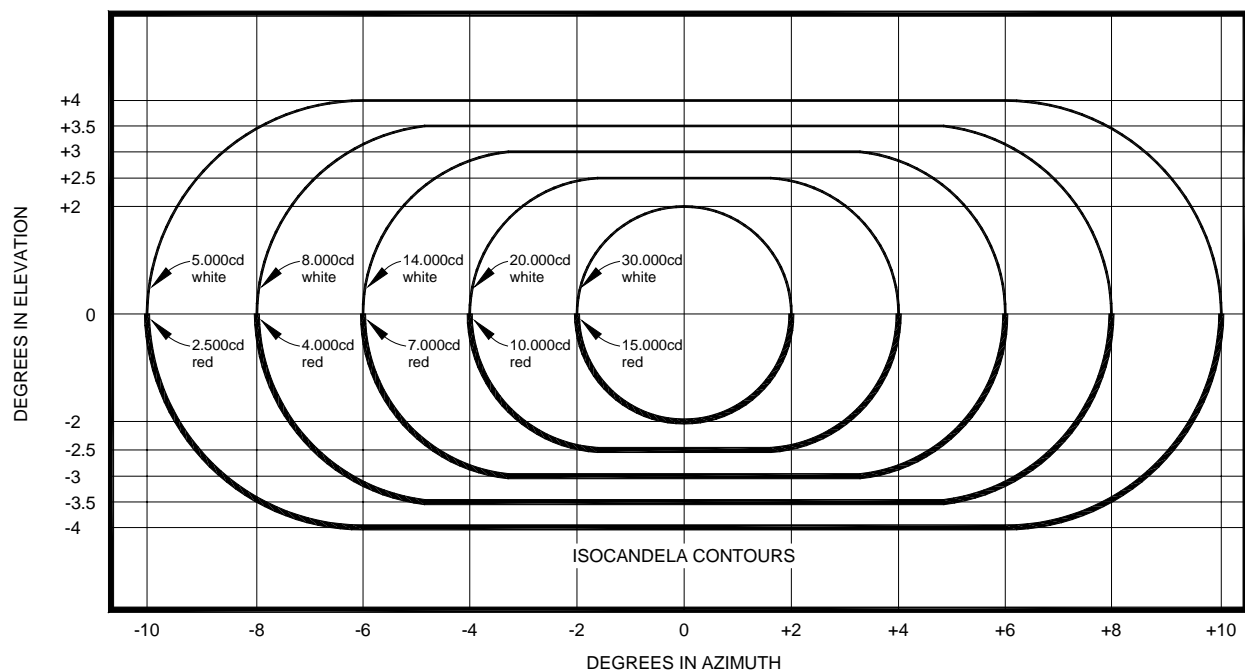


Figure 1. PAPI Light Distribution Requirements

- g. The PAPI light colors must be aviation white and red and meet the requirements of SAE AS25050, Colors, Aeronautical Lights and Lighting Equipment, General Requirements for, paragraph 3.1, Aviation Colors.

- h. Light transmitting covers must conform to the requirements of MIL-C-7989, Covers, Light Transmitting, for Aeronautical Lights, General Specification for, Paragraph 1.2, Classification, Class B.
- i. Lamps with a minimum rated life of 1000 hours must be used in this application.
- j. Lamps must be at their full intensity within 5 seconds after a cold start.

3.9.2 Light Unit Construction

- a. Light unit dynamic loading from wind, or static loading from snow or ice accumulation, must not cause the light pattern to shift.
- b. The weight of each light unit must not exceed 100 pounds (45 kilograms).

NOTE: *If the PCU is part of the light unit, the combined unit weight must not exceed 150 pounds (68 kilograms).*

- c. A light unit may not be higher than 40 inches (1 meter) at its maximum height when installed at its minimum mounting height.
- d. The light unit must use a protective overhang or other method to prevent rain or snow from accumulating on its lens surfaces.

3.9.3 Light Unit Mounting Provisions

3.9.3.1 Mounting Legs

- a. A minimum of three adjustable mounting legs must be used for leveling the light unit when one side of the unit is installed up to 1 inch (25 millimeters) higher or lower than the opposite side.
- b. At a minimum, the mounting legs must include:
 - (1) a light housing mounting and level adjusting hardware;
 - (2) frangible couplings under FAA drawing C-6046;
 - (3) and flanges for mounting the light unit on a concrete pad.

NOTE: *2 inch electrical metallic tubing (EMT) must be furnished by the installer.*

3.9.3.2 Adjusting Hardware

Any adjusting hardware must be vibration resistant and prevent movement of the optical system.

3.9.4 Light Unit Adjustments

3.9.4.1 Vertical Adjustment

All light units must use built-in adjustments for accurate vertical positioning of the light beam center at any elevation between 2 and 8 degrees.

NOTE: *The center of the light beam is the transition band between red and white light.*

Light Beam Aiming

An aiming tool must be furnished with the PAPI system. The tool must measure the vertical angle of the light beam center from 2 to 8 degrees in graduated increments of 10 minutes of arc. The aiming tool must have a repeatable accuracy of ± 3 minutes of arc.

3.9.4.2.1 Alternate Light Beam Aiming

Light units may be factory calibrated to a fixed vertical angle specified by the purchaser. The manufacturer must provide a procedure to check the calibration of the aiming system in the field with an accuracy of ± 3 minutes of arc.

3.9.5 Excessive Light Unit Tilt

The unit design must ensure all lamps in the system are de-energized when one light unit is lowered more than $\frac{1}{4}$ degree or raised greater than $\frac{1}{2}$ degree.

- a. The unit design must ensure all lamps in the system are de-energized when the optical pattern of one light unit is inadvertently lowered between $\frac{1}{4}$ and $\frac{1}{2}$ degree or raised between $\frac{1}{2}$ degree and 1 degree with respect to the preset aiming angle.
- b. A delay between 10-30 seconds before de-energizing the light units must be used to prevent intermittent activation caused by vibration or other movement.
- c. The light unit tilt sensing must be fail-safe so any malfunction, including loss of input power, de-energizes the PAPI light units.

3.9.6 Light Unit Electrical Wiring

Factory molded plugs must be on the exterior end of the wiring which penetrates the PAPI enclosure.

3.9.6.1 Lead Length

Power leads must be long enough to extend from the light unit, through a flexible conduit, and to a breakaway connector at ground level.

3.9.6.2 Strain Relief

Strain relief must be used on any light unit power leads.

3.9.6.3 Plugs

- a. Style B systems must use Class A, Style 1 or 6 plugs per AC 150/5345-26, *Specification for L-823, Plug and Receptacle, Cable Connectors*, to mate with the output lead of the isolation transformer.
- b. Style A systems may use any plug with a capacity and electrical performance equivalent to an L-823 plug.

3.9.6.3.1 Style B Alternate Plug System

The manufacturer may furnish an alternate harness that accepts the output of several transformers and combines them into a single receptacle for use in the transformer housing. The receptacle must be located just below the light unit's frangible coupling and mate with a compatible plug from the light unit.

3.10 Power and Control

3.10.1 Style A Systems

The PAPI power supply and control functions may be enclosed in a separate power and control unit (PCU) or inside a light box.

3.10.2 PCU Cabinet

- a. The PCU cabinet must be an enclosure that meets the National Electrical Manufacturers Association (NEMA) Type 4 rating.
- b. The PCU cabinet must contain all the power and control functions for a PAPI system.
- c. The cabinet door must open to 110 degrees minimum and equipped with a locking device to ensure it remains open during field maintenance.
- d. The cabinet must be furnished with a padlock hasp to secure the cabinet door when necessary.

3.10.3 Power

- a. The PAPI Style A system must operate from any standard utility single-phase alternating-current service voltage less than 600 volts.
- b. A trip-free circuit breaker must be furnished to allow de-energizing the PAPI system power.

3.10.4 Style A Voltage Regulation

The lamp socket voltage must be adjustable and regulated within 3 percent of its design value on the brightest step under the following conditions:

- a. the input line voltage deviates up to 10 percent above or below its nominal value;
- b. the individual light units are spaced between 20 feet (meters) and 30 feet (10 meters) apart;

- c. the Power Control Unit is located from 0 to 100 feet (30 meters) from the nearest light unit.

3.10.5 Style A Lamp Failure

When one or more lamps fail, it may not cause damage to either the power supply or the remaining lamps.

3.10.6 Photoelectric Intensity Control

The PAPI must be equipped with a photoelectric type control that automatically switches the lamps between two operating modes:

- a. Day mode - 90 to 100 percent lamp intensity.
- b. When the system is first energized, and daylight is detected, the night mode must be selected between 2 to 3 seconds before switching to the day mode.
- c. The photoelectric intensity control must have a delay between 45 to 75 seconds before switching lamp intensity to prevent unintentional switching caused by transient light, shadows, or transient voltages.

3.10.7 PAPI Remote Control

The PAPI must be provided by the manufacturer with the capability to be turned on and off from a remote location. The remote control may be by a hardwired cable or a radio frequency controller (specified in AC 150/5345-49, *Specification L854, Radio Control Equipment*).

3.10.8 Style A Night Mode Illumination Intensity

There must be two selectable night mode intensity settings, approximately 5 and 20 percent of the photometric distribution shown in Figure 1, to adapt the PAPI to airport ambient light levels.

3.11 Style B Systems

- a. Style B systems must operate from a series lighting circuit with a current range of 2.8 to 6.6 amperes.

NOTE: *PAPI remote control may be accomplished by sensing the current in the associated runway circuit during night operations.*

- b. The lamps in Style B systems must be compatible with an isolation transformer size per AC 150/5345-47, *Isolation Transformers for Airport Lighting Systems*.

NOTE: *Components of the series lighting circuit (for example: L-828 regulator, isolation transformer) will not be supplied with the PAPI system.*

3.11.1 Failure of Style B Lamp

Lamp failures must not cause damage to either the power supply or the remaining lamps.

3.11.2 Style B Lamp Shorting Device

A lamp bypass device to short circuit the socket of a burned out lamp must be available upon request by the customer.

3.12 PAPI Lamp Monitor

The manufacturer may offer an optional go/no go type PAPI lamp monitoring output.

3.13 PAPI System Control

3.13.1 Day Mode Illumination Intensity

- a. PAPI day mode must be selected when the illumination on a vertical surface facing north rises to 50 to 60 foot-candles.
- b. The PAPI must remain in the day mode until the illumination decreases to 25 to 35 foot-candles.

3.13.2 Night Mode Illumination Intensity

- a. The night mode must be selected when the illumination on a vertical surface facing north decreases to 25 to 35 foot-candles.
- b. When the PAPI has switched to night mode, it must remain in the night mode until the illumination rises to 50 to 60 foot-candles.

3.13.3 Photoelectric Intensity Control Failure

The PAPI must automatically switch to night mode if the photoelectric control fails.

3.14 Transient Suppression

3.14.1 Style A Surge and Transient Protection

The PAPI equipment susceptibility to power line surges must be per the defined waveforms detailed in Table 4, Location Category C1, in ANSI/IEEE C62.41-1991, *Recommended Practices on Surge Voltages in Low Voltage AC Power Circuits*. Surge protection must be provided against a minimum of 3 applications at 15 second intervals of a 3,000 peak amp 8/20 microsecond (μ S) short circuit current pulse and 6000 volt 1.2/50 μ S open circuit pulse.

NOTE: *Series lighting circuits for Style B PAPI systems already have integral lightning protection on the regulator output. However, if any solid state components are used, paragraph 3.14.1 must apply.*

3.15 Equipment Grounding

Conductive materials enclosing electrical conductors, equipment, or housings within the equipment must be connected to a common lug that allows connection to the system ground conductor.

3.16 Equipment Finish

The exterior of all PAPI units must be painted International Orange, Federal Color Number 12197, per FED-STD-595.

3.17 PAPI Parts and Materials

- a. All PAPI system parts and materials must meet the environmental requirements in this AC.
- b. All parts and materials must be protected against corrosion.
 - (1) All fasteners and other hardware must be compatible with the material joined and may not cause galvanic corrosion.
- c. PAPI system components may not be operated in excess of the component manufacturers recommended rating.
- d. Plastic components exposed to sunlight must be oxidation and ultraviolet resistant.

3.18 PAPI Maintenance

- a. The PAPI system must be designed for ease of maintenance so field repairs and routine maintenance can be accomplished without special tools.
- b. If lamp defocusing occurs after lamp replacement, the manufacturer must furnish any special tools and procedures required for refocusing.
- c. If any special tools are required for other than routine maintenance and field repairs, the manufacturer must furnish them.

3.19 Workmanship

The equipment must be fabricated under the highest quality commercial standards of workmanship.

3.20 PAPI Instruction Book

An instruction book containing the following information must be furnished with each system:

- a. System schematic and wiring diagrams showing all components cross-indexed to the parts list;
- b. Parts list with:
 - (1) part name,
 - (2) part rating,
 - (3) physical characteristics of the part,
 - (4) component manufacturer's name and part number.

- c. Installation instructions, including procedures for aiming, calibration of the aiming system, focusing, and adjustment of the excessive tilt mechanism;
- d. Maintenance instructions, including re-lamping procedure, theory of operation and trouble-shooting charts.
- e. Operating instructions.

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4. PAPI QUALIFICATION REQUIREMENTS

- a. Procedures for qualification approval are in AC 150/5345-53, *Airport Lighting Equipment Certification Program*.
- b. The following tests are required to demonstrate compliance with this AC. All tests may be performed on the PAPI power supply and a single light unit; any other units may be simulated by a resistive load.

4.1 Visual Examination

The equipment must be examined for compliance with the requirements in this AC for size, weight, materials, finish, and quality of workmanship.

4.2 High Temperature Test

- a. A high temperature test must be conducted per MIL-STD-810F, method 501.4, Procedure II.
- b. The equipment must be exposed to 131 degrees F (+55 degrees C) for 4 hours after temperature stabilization.
- c. The equipment must be operated during the temperature test.
- d. Any deterioration in materials or system performance must be considered a test failure.

4.3 Low Temperature Test

- a. A low temperature test per MIL-STD-810F, Method 502.4, Procedure II must be conducted.
 - (1) For Class I systems, the equipment must be exposed to -31 degrees F (-35 degrees C) for 24 hours.
 - (2) For Class II systems, the equipment must be exposed to -67 degrees F (-55 degrees C) for 24 hours.
- b. The equipment must be operated after temperature stabilization at the beginning and prior to the end of the test.
- c. No accumulation of dew or frost must be evident on any portion of the PAPI front lens surfaces.
- d. Any deterioration in materials or performance must be considered a test failure.

4.4 Rain Test

- a. A wind-blown rain test must be conducted per MIL-STD-810F, Method 506.4, Procedure I.
- b. The rain must be at a rate of 5.2 inches/hour (130 millimeters/hour) with an exposure time of 30 minutes per side.
- c. The equipment must be operated during the test.

- d. Any deterioration of system performance or excessive accumulation of water in equipment cabinets must be considered a test failure.

4.5 Salt-Fog Test

- a. A salt-fog test must be conducted per MIL-STD-810F, Method 509.4, Procedure 1.
- b. The test duration must be 48 hours exposure and 48 hours drying.
- c. Any evidence of damage, rust, pitting, or corrosion (sacrificial coatings are excepted) must be considered a test failure.

4.6 Wind Loading

Using either wind tunnel tests or static loading, it must be demonstrated the system can withstand a 100 mph (161 km/hr.) wind load from any azimuth direction without displacing the optical pattern more than allowed in the rigidity test in paragraph 4.11.

4.7 Frangibility Test

The frangibility of the PAPI mounting legs must be demonstrated to be the same as the 2-inch frangible coupling depicted in FAA drawing C-6046.

4.8 Transient Suppression Test

The test waveforms applied to the equipment must be per paragraph 3.14.1.

4.9 Photometric Tests

- a. A photometric test for the color, intensity, and beam pattern requirements of paragraph 5 in this AC must be conducted.
- b. All lamps used for photometric testing must be randomly selected from a production lot.
- c. The photometric requirements in paragraph 3.9.1 must be tested for one set of lamps.
- d. To demonstrate repeatability, the intensity along the horizontal and vertical axes for two additional sets of lamps must be checked.
- e. If any refocusing is required after lamp replacement, it must be accomplished using the manufacturer's FAA approved procedure to demonstrate that the required photometrics are reproduced.
- f. Any test equipment must be calibrated before testing.
- g. All measurements must be taken at a distance that allows full focusing of the beam.

4.9.1 Chromaticity Tests

The PAPI must be tested at full intensity with the lamps, filters, and optical system used to ensure that it meets chromaticity requirements.

- a. Spectral transmittance measurements of the filter must be performed at the specified operating temperatures of the lamps.
- b. The PAPI must meet the chromaticity requirements of AS 25050 when tested at full brightness at the center of the main beam and the extremes of the horizontal and vertical beam distribution. Chromaticity outside of distribution boundaries may be verified visually.

4.10 Lens Certification

A certificate of compliance must be furnished from the lens manufacturer stating that the light unit lenses meet:

- a. The requirements in MIL-C-7989.
- b. The color requirements in AS-25050.

4.11 Light Unit Rigidity Test

This test applies a static load equivalent to the maximum light unit design wind loading and determines if there is any movement of the light pattern.

- a. Before applying the static load, the light unit must be set up and the light pattern displayed on a vertical surface 20 feet (6 meters) in front of the light unit.
- b. The top, bottom, and the sides of the light unit beam pattern must be marked on the vertical surface in paragraph 4.11a.
- c. A uniformly distributed sand load or other suitable material of 15 pounds per square foot (73 kilograms per square meter) must be applied over the entire top surface of the light unit.

NOTE: *A framework or other method may be used to ensure the sand used to load the light unit does not spill over its sides.*

- d. The load must be applied by allowing the sand pour down on the center top surface of the light unit.
- e. The sand load must be left in place for 5 hours.
- f. After 5 hours has elapsed, the light housing beam pattern must be checked for any movement from the original marks drawn in paragraph 4.11b. The light unit beam pattern must be within +1/4 inch (6 millimeters) of the original markings.
- g. Remove the sand load.
- h. The beam pattern must be checked against the markings in paragraph 4.11b, and mark any movement. The light unit beam pattern must be within +1/4 inch (6 millimeters) of the original markings.

4.12 Aiming Device Test

- a. The PAPI aiming device must be checked, using the manufacturer's procedure (approved prior to testing by the FAA), to demonstrate that when the light unit is moved by the adjustment mechanism, the measuring device indicates the change with an accuracy of ± 3 minutes of arc.
- b. The measuring device must be checked at one degree intervals from 2 to 8 degrees.

4.13 Operational Test

- a. A PAPI system operational test, using the manufacturer's test procedure (approved prior to testing by the FAA), must be conducted to demonstrate compliance with all operating requirements.
- b. The manufacturer's procedure must test:
 - (1) the excessive tilt mechanism;
 - (2) the power supply performance (current, voltage while at full brightness);
 - (3) the photoelectric controller;
 - (4) operation with one lamp out per light unit and verify proper voltage is still applied to the sockets of the operational lamps;
 - (5) if the failure of a lamp produces transients or over-voltage conditions that damage the remaining lamps.

5. PRODUCTION TESTS

- a. A test procedure that verifies the light output and aiming device accuracy for each production unit must be submitted to the FAA for approval.
- b. After FAA approval, the test procedure must be used for all production units.
- c. The visual examination in paragraph 4.1 and the operational test in paragraph 4.13 must be performed for each production system.

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