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Superseding ARP6402

LED Landing, Taxiing, Runway Turnoff, and Recognition Lights

RATIONALE

ARP6253 LEDs and Aircraft Applications is one of the references for this document. The number and title of ARP6253 changed during document development, which paralled the development of ARP6402. The change was not incorporated in the references, and this revision is for the purpose of correcting that oversight.

FOREWORD

This document provides guidance material for the design, qualification, certification and use of LED based Landing, Taxiing, Runway Turnoff Lights, and Recognition Lights.

1. SCOPE

This document includes recommendations of installations of adequate landing and taxiing lighting systems in aircraft of the following categories:

a. Single engine personal and/or liaison type

b. Light twin engine

c. Large multiengine propeller

d. Large multiengine turbojet

e. Military high performance fighter and attack

f. Helicopter

which are subject to the following CFR Parts certification:

Part 23 – Airworthiness Standards: Normal, Utility, Acrobatic and Commuter Aircrafts

Part 25 – Airworthiness Standards: Transport Category Aircrafts

Part 27 – Airworthiness Standards: Normal Category Rotorcraft

Part 29 – Airworthiness Standards: Transport Category Rotorcraft

1.1 Purpose

The purpose of this document is to provide certain basic considerations and design criteria for installation of LED landing, runway turnoff, and taxiing light systems for night operation. Criteria for recognition lights are also included.

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http://www.sae.org/technical/standards/ARP6402A

2. REFERENCES

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of the other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

ARP6253 LEDs and Aircraft Applications

ARP693 Landing and Taxiing lights – Design Criteria for Installation

J1330 Photometry Laboratory Accuracy Guidelines

2.2 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

Federal Aviation Regulations, Part 23, Airworthiness Standards: Normal, Utility, and Acrobatic Category Aircrafts.

Federal Aviation Regulations, Part 25, Airworthiness Standards: Transport Category Aircrafts.

Federal Aviation Regulations, Part 27, Normal Category Rotorcraft.

Federal Aviation Regulations, Part 29, Transport Category Rotorcraft.

Federal Aviation Regulations, Part 121, Certification and Operations: "Domestic, Flag and Supplemental Air Carriers and Commercial Operators of Large Aircraft."

Federal Aviation Administration AC25-7A 9 Flight Test Guide for Certification of Transport Category Aircrafts

2.3 U. S. Government Publications

Available from the Document Automation and Production Service (DAPS), Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, Tel: 215-697-9495, https://assist.daps.dla.mil/quicksearch/.

MIL-L-6503 Military Specification, Lighting Equipment, Aircraft, General Requirements For

3. DEFINITIONS

HALATION: Scattering of a light beam beyond its proper boundaries, causing a bright ring or halo surrounding an object or beam of light.

GLARE: Light within the visual field that is brighter than the level to which the eyes are adapted, thus reducing visibility, reducing contrast, annoying, causing discomfort, or distracting the observer.

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4. GENERAL RECOMMENDATIONS

4.1 Color to be white. Flight test for certification shall include an assessment to determine adequate color discrimination for runway and taxiway signs as well as color contrasts between pavement and surrounding environment for orientation of aircraft on runways and taxiways.

4.2 The amount of ultraviolet light should be considered due to possible negative effects on materials and observers.

4.3 LEDs generally do not fail catastrophically, but experience gradual degradation in light output over time. The rate of degradation is dependent upon many factors including, the LED component materials, drive current, operating environment and LED junction temperature. Due to the lack of a hard failure point, it is desirable to define the photometric end of life (EoL). EoL can be defined as a percentage of initial output (70% for many applications), or the length of operational time until the light no longer meets defined minimum intensities. Because photometric margin and life can be impacted by adjusting package size, weight, power and cost, establishing specific values / requirements for life is not appropriate as these requirements can be market / platform / installation specific. An appropriate EoL requirement does, however, need to be considered during the design / installation process in order to insure that the lights will meet their intended function for the duration of their rated life.

4.4 Icing, humidity, and condensation should be considered in the design of the lighting system due to effects on system performance. Appropriate draining and/or venting are recommended.

4.5 Warm up and stabilization: For purposes of demonstrating compliance with this specification, all photometric and color measurements shall be made after a minimum warm up period (30 minutes for LED sources, 90 seconds for incandescent/tungsten halogen light sources), or after the light has reached thermal stabilization, whichever is longer. Stabilization shall be defined as the point in which light output does not change by more than 3% over a 15 minute period.

5. DETAILED RECOMMENDATIONS

Landing Light Classes (See Table 1) The performance levels found in table 1 may be used as guidelines in the design of LED landing lights. Recommended end of operating hours is 1000 hours minimum. Power consumption and heat loading should be taken into account in design of wiring, circuit protection, and enclosure materials.

5.1 General Provisions

5.1.1 Landing lights are used primarily to provide ground reference information during final approach, touchdown, ground roll, and takeoff, and to illuminate any major obstructions in the aircraft approach glide path or on runway at night.

5.1.2 Landing lights may also be used for signaling purposes in flight. The landing lights may be turned "on" when:

a. Operating within 10 miles of any airport, day or night

b. Operating in conditions of reduced visibility, i.e., haze, dust, etc.

c. Operating under special visual flight rules (VFR) conditions

d. Operating where flocks of birds may be expected (coastal area, swamp lands, migratory areas, etc.)

This requires that all or some landing lights are functional when gear and slats/flaps are retracted.

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TABLE 1 - LAMPS FOR LANDING SERVICE

NOTE: The lamp classes listed below represent current industry usage typical for this type of installation with incandescent light sources.

Lamp Class	Volts	Beam Maximum Candela on Centerline	Minimum Horizontal Nominal Beam Spread to 10% of Center Beam Candela (deg)	Minimum Vertical Nominal Beam Spread to 10% of Center Beam Candela (deg)	Category See Section 1
1a	14	110 000	12	6	a
1b	28	110 000	12	6	a
2a	14	200 000	12	6	a,b
2b	28	200 000	12	6	a,b
3	28	300 000	12	6	b
4	28	400 000	13	13	b,e,f,
5	28	600 000	12	12	c,d,f
6	28	800 000	12	6	c,d,f,
7	28	300 000	15	9	c,d

Performance levels found to be acceptable in flight test may take the place of the recommendations found in Table1. Please note that lights do not always conform to their specification sheet performance levels. Performance will be affected if cover lenses are used.

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5.1.3 Each landing light should be designed and be installed such that:

a. No objectionable glare is visible to the pilot.

b. The pilot is not adversely affected by halation.

c. Reference CFR §23.1383(a), (b), (c), (d); §25.1383(a),(b),(c); §25.773(a); § 27.1383(a),(b),(c); § 29.1383(a),(b),(c).

5.1.4 Each landing light should provide sufficient illumination on the runway for night landing. As a design objective, 21.5 lux (2 ft-c) minimum at 122 M (400 ft) in front of the pilot at touchdown attitude and 5.4 lux (0.5 ft-c) minimum at 91 M (300 ft) in front of the pilot during ground roll should be provided for aircraft categories C and D. Lux (Ft-c) levels are measured normal to the light beam.

It should be noted that normal approach attitude varies between particular aircrafts, depending upon speed, flap conditions, etc. In most cases, the landing attitude and taxiing attitude of the aircraft are not the same; however, the landing lights should accommodate adequate light coverage for final approach, touchdown, and ground roll illumination. So, for some aircrafts, it may be necessary to re-aim the landing lights, once the aircraft is on the ground.

5.1.5 Minimum recommended number of landing lights for night flying are listed in Table 2.

TABLE 2 - RECOMMENDED NUMBER OF LANDING LIGHTS FOR DIFFERENT CATEGORY AIRCRAFT

Aircraft Categories	Minimum Number of Landing Lights
Single engine personal and/or liaison type	2
Light twin engine	2
Large multiengine propeller	3
Large multiengine turbojet	4
Military high performance fighter and attack	2
Helicopter:	
Retractable landing light	1
Searchlight (may be used as landing light)	1

NOTE: The recommended quantities listed in Table 2 refers to equipment installation only and should not be misinterpreted as quantities required for aircraft dispatch.

5.1.6 Possible locations of lights are recommended as follows:

a. Typical locations of Landing Lights:

1. Nose landing gear strut
2. Each side of fuselage (ahead of wing)
3. Wing/body strake (wing root)
4. Flap track fairing
5. Lower wing surface (retractable), fuselage lower surface or side (retractable), or wing leading edge
6. Nose
7. Helicopter skid assembly

b. Typical locations of Runway Turnoff/Taxi Lights:

1. Nosewheel gear (steerable)
2. Nose landing gear strut
3. Wing/body strake (wing root)
4. Each side of fuselage (ahead of wing)

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5.2 Aiming and Illuminated Areas

It is recommended that adequate landing light aiming and illumination be provided to cover the following aircraft attitudes:

a. Prior to touchdown, the pilot will start using the lights as he initiates the flare. The landing light shall be aimed somewhat ahead of the pilot vision limit, and along the glide slope (see Figure 1).

b. Before the point of touchdown is reached, the aircraft is positioned in a nose up attitude and the centerline of the beam moves further down the runway relative to the pilot's field of vision. At touchdown, it is desirable to provide illumination of the runway centerline and possible obstructions as far as 122 M (400 ft) away from the pilot (see Figure 2).

c. After touchdown, the nosewheel gradually drops to the ground and the aircraft assumes a ground roll attitude. At this point, it is desirable to provide illumination of the runway centerline at least 91 M (300 ft) away from the pilot (see Figure 3).

d. Crosswind conditions should be considered in design of landing light installations.

5.3 Installation and Relamping

It is recommended that the landing light fixture contain provisions to orient the lamp to assure the correct horizontal and vertical beam pattern (see Table 1) if applicable.

5.4 Controls

5.4.1 Each landing light shall be controlled by a separate switch [reference CFR § 25.1383 (b)] unless an equivalent level of safety has been demonstrated for a single switch installation.

5.4.2 One switch may be used for the lights of a multiple light installation at one location.

5.4.3 For retractable landing lights, it should be possible to turn the light on or off without altering the position of the light fixture by providing a separate switch controlling the motor drive circuit. This switch may allow aiming control at any position between fully extended and fully retracted position by the pilot.

5.4.4 There shall be a means to indicate to the pilots when retractable landing lights are extended [reference CFR § 25.1383 (c)] .

5.4.5 An automatic control switch should be provided to turn off the landing lights, which are installed in the wheel wells when the gears are retracted.

5.4.6 An automatic control switch may be provided to operate the externally mounted landing lights at dim mode when the landing gears are retracted due to high electricity consumption and possible heating of the lamp or other components of the aircraft. An indication shall be provided to the flight crew that this function is activated.

5.4.7 Consideration should be given to redundancy of lighting circuit and lamps to minimize the consequences of failures and improve dispatch reliability.

5.4.8 For rotary-wing aircraft the controllable searchlight should be so installed that when the light is fully stowed, the plane of the lamp mounting ring will be horizontal or the beam center should be directed straight down when the aircraft is in normal, level flight. The searchlight should be of a type that can be extended not less than 120 degrees from its fully stowed position.

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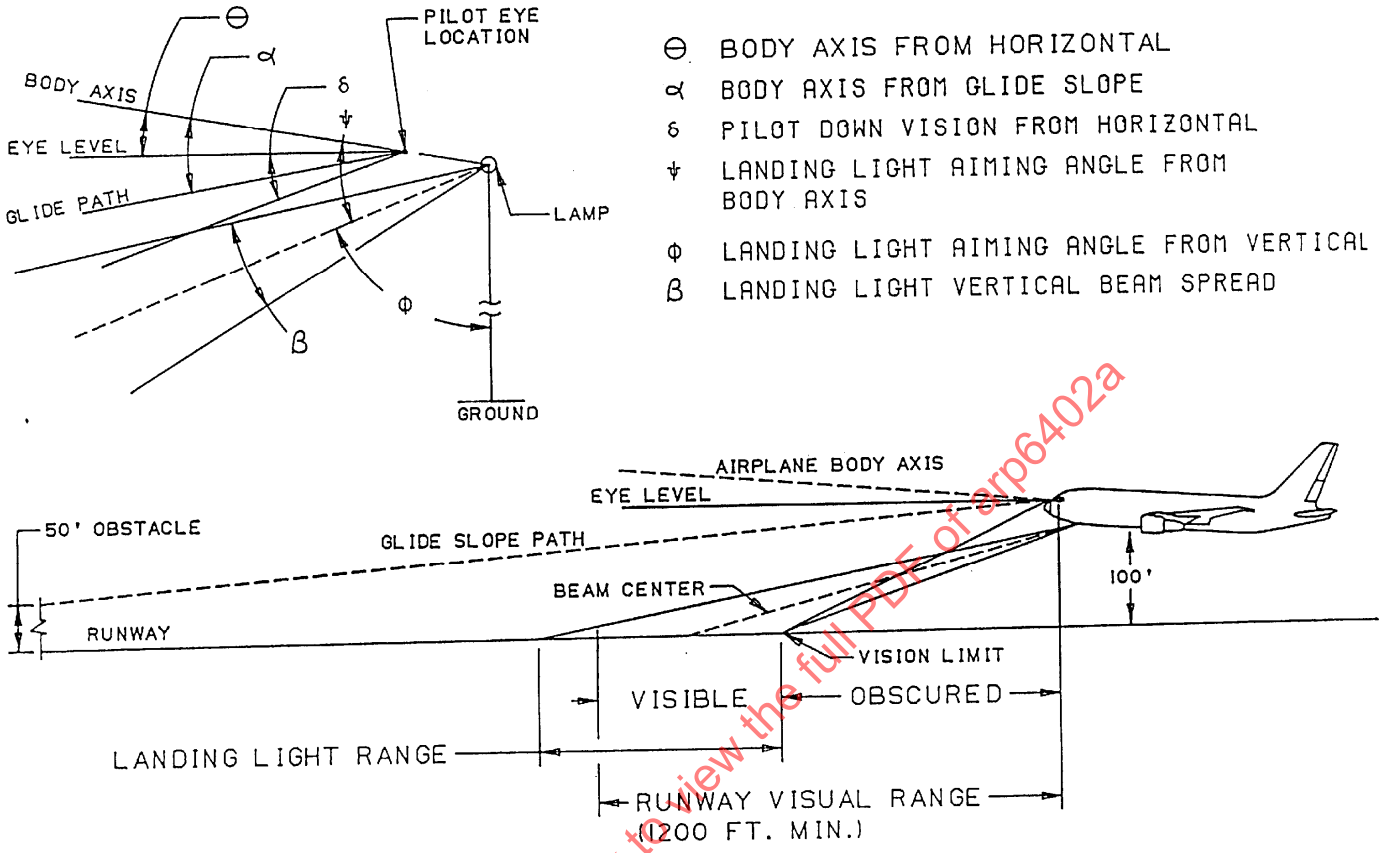

FIGURE 1 - LANDING LIGHT AT APPROACH ATTITUDE

POINT "A" SHALL BE LOCATED ON A LINE PERPENDICULAR TO THE AIRPLANE AXIS 400 FEET AHEAD OF THE PILOT ON THE RUNWAY. THIS POINT SHALL BE IN FRONT OF THE CENTER OF THE LIGHT BEAM.

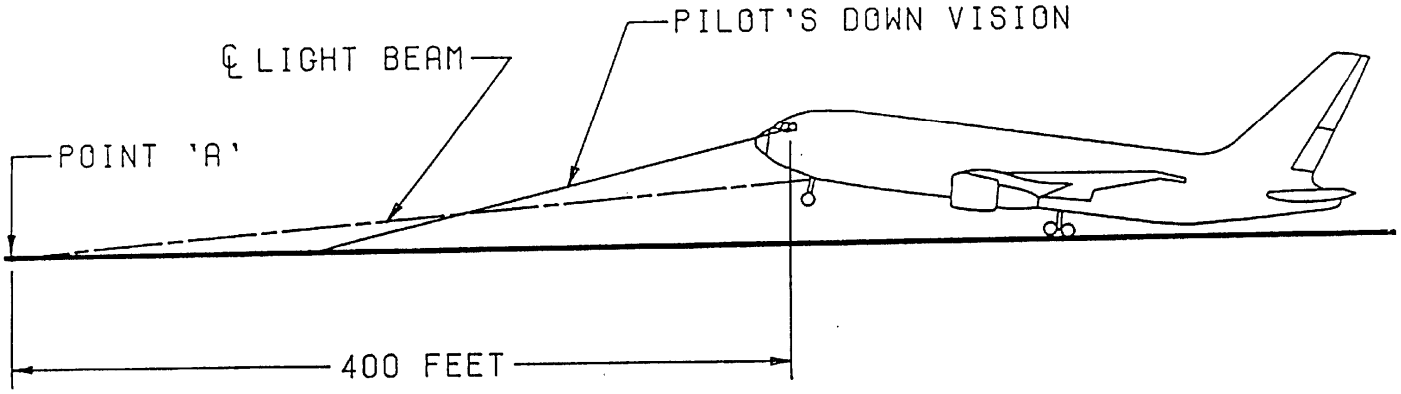

FIGURE 2 - LANDING LIGHT AT TOUCH DOWN ATTITUDE

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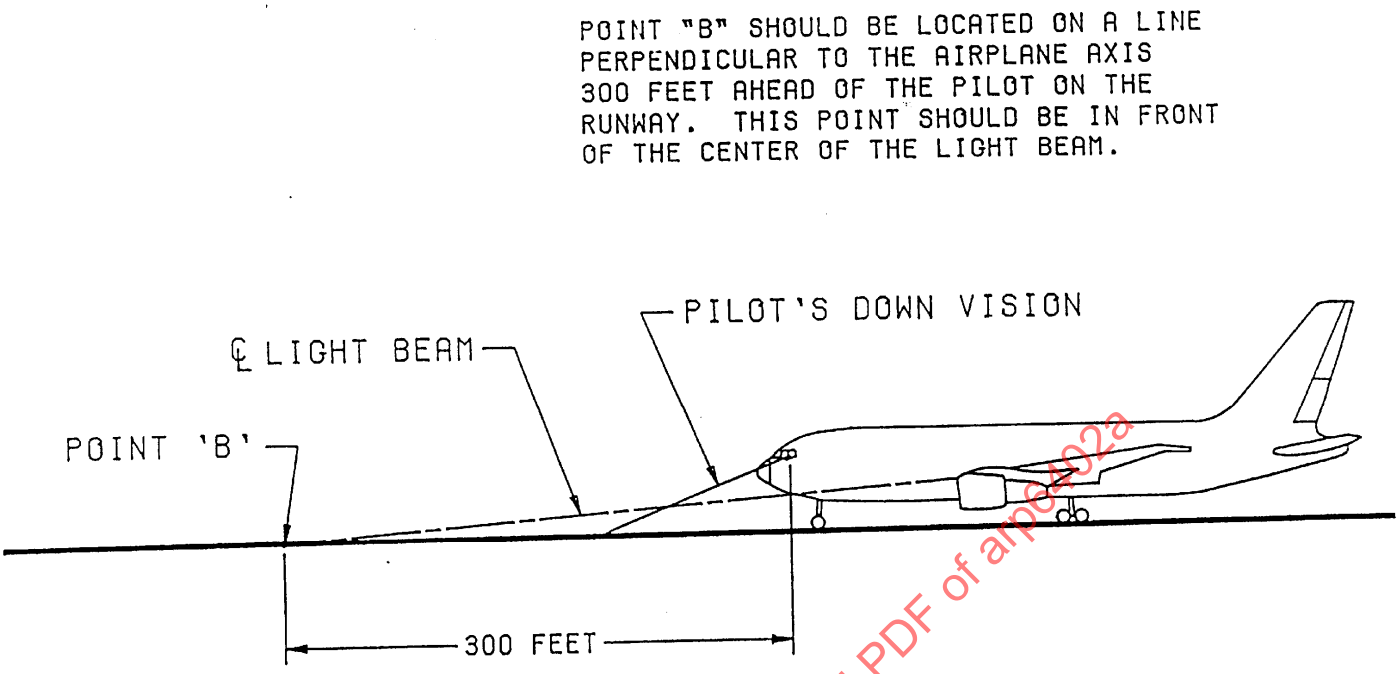

FIGURE 3 - LANDING LIGHT AT GROUND ROLL ATTITUDE

5.5 Runway Turnoff/Taxi Lights (See Table 3)

5.5.1 General Provisions

5.5.1.1 Taxi lights are used to maneuver the aircraft on the ground at night. Runway turnoff lights are used to augment the taxi light on large multiengine jet aircraft. The landing lights are normally switched off to conserve the lamps and to avoid blinding oncoming traffic.

5.5.1.2 Sufficient intensity and beam spread should be provided to aid the pilot in locating the following:

a. Taxiways (or painted centerline)

b. Runway turnoff locations

c. Obstructions which might contact any parts of the aircraft

The taxiing and runway turnoff lights should provide a minimum illumination on each side of the centerline of the aircraft to 3 M (10 ft) outboard from each wingtip, i.e. illumination 6 M (20 ft) wider than the wingspan.

As a design objective, 21.5 lux (2 ft-c) minimum at 15.25 M (50 ft) in front and 24.5 M (80 ft) outboard of the pilot should be provided for the runway turnoff light, and 54 lux (5 ft-c) minimum at 30.5 M (100 ft) in front of the pilot should be provided for the taxiing light respectively (see Figure 4) for aircraft categories C and D. Lux (Ft-c) levels are measured normal to the light beam. There should not be a non-illuminated gap visible between the taxi and turnoff light lit areas.

5.5.1.3 On small aircrafts landing lights may be used in place of taxi lights. If installed, a single lamp in the nose or on the nose wheel strut is usually sufficient.

5.5.1.4 On large aircrafts at least two runway turnoff lights should be required. The combination of both runway turnoff lights and taxiing lights would provide most desirable coverage, even in low visibility conditions.

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5.5.2 Aiming

It is recommended that runway turnoff lights be aimed so that the center of the beam of each light strikes the ground in normal taxiing attitude at 15.25 M (50 ft) minimum and 24.5 M (80 ft) outboard in front of the pilot as shown in Figure 4.

It is recommended that the taxiing light on the nosewheel be aimed in the direction of travel with the center of the beam horizontal. It is desirable to install the light on the nosewheel movable strut so that the light will turn laterally with the nosewheel strut.

5.5.3 Relamping

It is recommended that the runway turnoff/taxiing light fixture design contain provisions to orient the lamp to assure the correct horizontal and vertical beam pattern is achieved.

5.5.4 Control

The runway turnoff/taxiing light system should be operated independently from the landing light system by a separate switch.

Each runway turnoff/taxiing light should be controlled by a separate switch.

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TABLE 3 - LAMPS FOR TAXIING SERVICE

NOTE: The lamp classes listed below represent current industry usage typical for this type of installation with incandescent light sources.

Lamp Class	Volts	Initial Beam Maximum Candela on Centerline	Minimum Horizontal Nominal Beam Spread to 10% of Center Beam Candela (deg)	Minimum Vertical Nominal Beam Spread to 10% of Center Beam Candela (deg)	Category See Section 1
1a	14	10 000	40	7	a
1b	28	10 000	40	7	a
2	28	30 000	50	9	b,c
3	28	75 000	50	9	c,d,e,
4	14	75 000	50	9	c,d
5	28	90 000	50	16	c,d,e

Performance levels found to be acceptable in flight test may take the place of the recommendations found in Table3.
Please note that lights do not always conform to their specification sheet performance levels.
Performance will be affected if cover lenses are used.

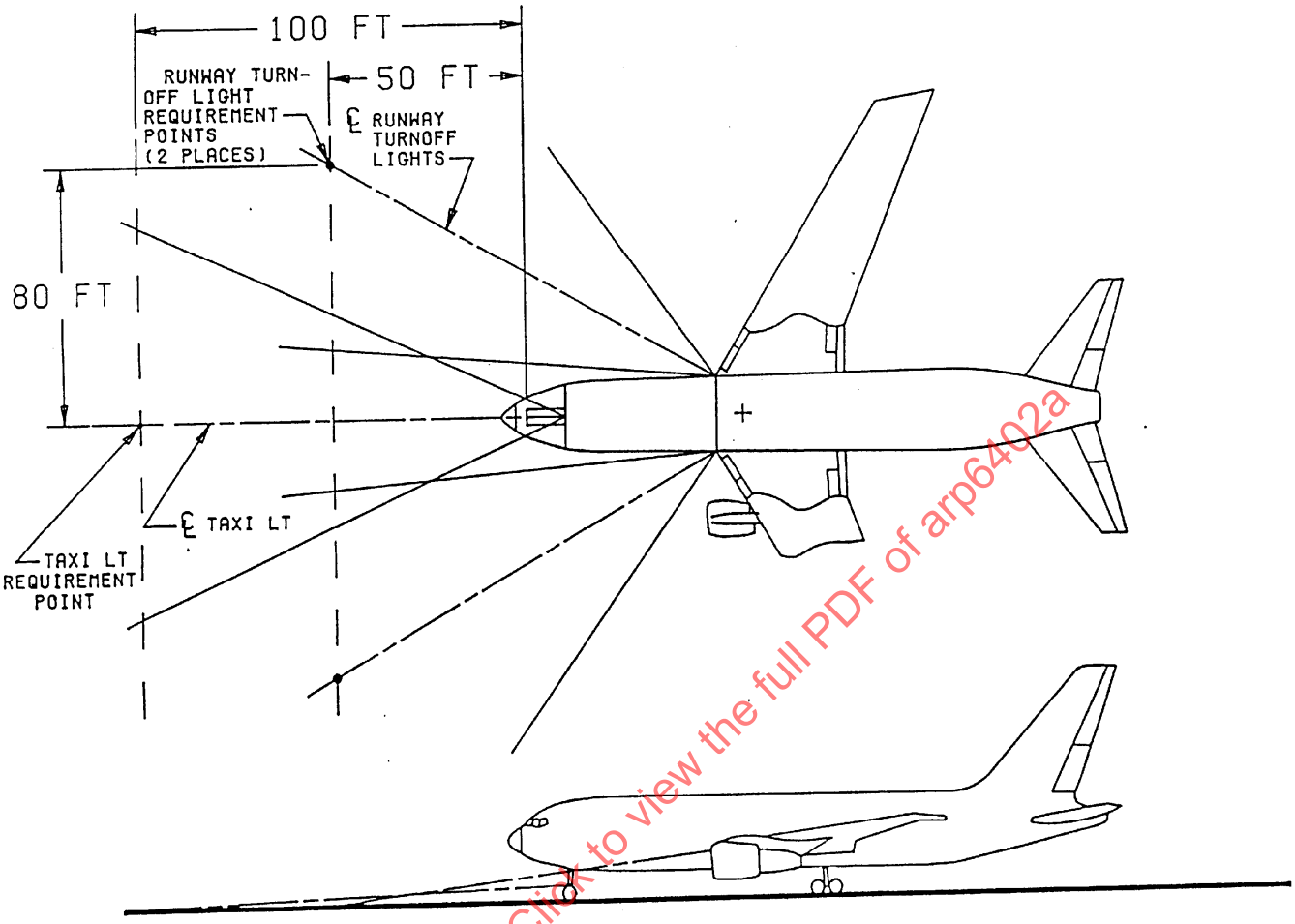

FIGURE 4 - TAXI AND RUNWAY TURNOFF LIGHT

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5.6 Recognition Lights

5.6.1 A recognition light function may be produced by steady burn or flashing landing or taxiing lights, or lights provided specifically for recognition.

5.7 Installation Design

5.7.1 All installations should pass photometric requirements in the thermal environment specified by the airframe manufacturer for the duration and conditions of the anticipated duty cycle. Environmental effects on photometry may be established by analysis.

5.7.2 Each light fixture, and its associated wiring and equipment (such as transformer or motor), mounted in or attached to the fixture, should be capable of withstanding all environmental conditions anticipated in ground and flight operation. The requirements of RTCA Document DO-160 may be used except where anticipated conditions are more severe.

5.7.3 Each light fixture and its attachment provisions should provide solid mounting to avoid amplification of vibration between aircraft structure and lighting fixture.

5.7.4 When light fixtures are installed in an area which can possibly contain explosive vapors, special design conditions shall be given to assure safe operation and explosion-proofing. FAA Advisory Circular 25.981-1A provides guidelines for components in close proximity to fuel tanks or tank surfaces.

5.7.5 All exposed terminals should be coated or guarded to eliminate the possibility of striking an arc.

5.8 Maintainability

Special consideration should be given to the installation of the lights so that the lamps can be changed in a reasonable amount of time. It should be replaced by using conventional tools without readjustment or re-aiming the light. For retractable landing lights, relamping should be accomplished in either the retracted position or extended position.

5.9 Light Loss Consideration

When light fixtures are mounted in a light well behind a heat resistant plastic or glass access window, as a design objective, the angle between the center of the light beam and the normal line of the lens should be limited up to 60 degrees to alleviate light distortion and minimize loss of illumination.

5.10 Location Considerations

The light fixtures should be installed such that they will not induce sensing error or other negative effects in flight instruments or other safety items.

5.11 Operation Parameter (Retractable Landing Light)

5.11.1 The light should have a positive means of preventing the lamp from extending or retracting to a position that will cause damage to the unit or structure.

5.11.2 The light should have an overload protection device that will interrupt the motor circuit at a frontal load specified in the procurement document. The device should protect the motor until the overload is removed, and the light should operate normally.

5.11.3 The light should be capable of extending and retracting within a maximum time specified in the procurement document. Fifteen seconds is the maximum recommended.

5.11.4 The light should be capable of operating without damage, during normal flight conditions throughout the design speed envelope of the aircraft.

5.11.5 The lights for supersonic aircraft should be designed with a clutch or other drive release mechanism which would permit the light to retract if air loads become excessive. This would allow retraction of the light in case of failure of normal operation mechanism and then prevent possible buffeting and early structure fatigue by extension at supersonic speeds.

5.11.6 Under icing conditions the motor should not be stalled and should extend and retract the light.

5.11.7 The light should be designed to minimize aerodynamic drag.

5.11.8 The light may be designed to provide light aiming at any position between fully extended and fully retracted if specified in the procurement document.

5.12 Safety Practice

The safety and performance of the lighting system in all environments are dependent on the effectiveness of the electrical bonding and grounding system. The impact of the designer's approach on the design should be evaluated in early design configurations to ensure that system performance and safety are "designed in," rather than added later in the form of unnecessary weight, substandard compromise or costly "fixes."

5.12.1 Current Return Ground

A design objective on exterior light equipment installation should be to prohibit using the case as a current return ground. The preferable way to provide separate current returns is through the equipment connector or a terminal lug. Care should be exercised in providing current return leads which are properly sized to be protected by the input circuit breaker. The ground lead size should be at least equal to the power input lead size.

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