AEROSPACE RECOMMENDED PRACTICE

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Superseding ARP693E

Landing and Taxiing Lights -
Design Criteria for Installation

RATIONALE

This document covering older, established technology is stabilized. Refer to ARP6402 for updated guidance.

STABILIZED NOTICE

This document has been declared "STABILIZED" by SAE A-20B Exterior Lighting Committee and will no longer be subjected to periodic reviews for currency. Users are responsible for verifying references and continued suitability of technical requirements. Newer technology may exist.

FOREWORD

The recommendations set forth herein are the results of the combined efforts of engineers associated with the manufacture of lamps, equipment, and airframes, as well as engineers from the air transportation field and interested government agencies.

This SAE Aerospace Recommended Practice (ARP) does not include recommendations for the use of any specific equipment.

1. SCOPE

This document includes requirements 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/turbofan

e. Military high-performance fighter and attack

f. Helicopter

This document will cover general requirements and recommended practices for all types of landing and taxi lights. More specific recommendations for LED lights in particular can be found in ARP6402.

1.1 Purpose

The purpose of this document is to provide certain basic considerations and design criteria for installation of landing and taxiing light systems for night operation. These recommendations can be used to provide criteria for adequate lighting for the FAA or other certifying authority.

2. REFERENCES

2.1 Applicable Documents

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 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.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP881 Lamps for Aircraft Lighting

ARP6402 LED Landing, Taxiing, Runway Turnoff, and Recognition Lights

AS580 Pilot Visibility from the Flight Deck Design Objectives for Commercial Transport Aircraft

SAE J1330 Photometry Laboratory Accuracy Guidelines

2.1.2 FAA Publications

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

14 CFR Part 23.1383, Airworthiness Standards: Normal, Utility, and Acrobatic Category Airplanes

14 CFR Part 25.1383, Airworthiness Standards: Transport Category Airplanes

14 CFR Part 27.1383, Normal Category Rotorcraft

14 CFR Part 29.1383, Transport Category Rotorcraft

14 CFR Part 121, Certification and Operations: "Domestic, Flag and Supplemental Air Carriers and Commercial Operators of Large Aircraft"

Aeronautical Information Manual 4-3-23. Use of Aircraft Lights section c.

Federal Aviation Administration Advisory Circular AC 25-7A Flight Test Guide for Certification of Transport Category Airplanes

Federal Aviation Administration Advisory Circular AC 150 Airport design

2.1.3 U. S. Government Publications

Copies of these documents are available online at http://quicksearch.dla.mil.

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

2.1.4 RTCA Publications

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

Radio Technical Commission for Aeronautics (RTCA) Document No. 160, Environmental Conditions and Test Procedures for Airborne Equipment

2.2 Other Publications

Available from https://books.google.com.

Forward Vehicular Lighting and Inclement Weather Conditions, John D. Bullough and Mark S. Rea, Rensselaer Polytechnic Institute. (Progress in Automobile Lighting 2001: Proceedings of the Symposium)

Photometric Indicators of Headlamp Performance, John M. Sullivan and Michael J. Flannagan, University of Michigan Transportation Research Institute. (UMTRI-2009-18)

2.3 Related Research

Available from U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services, National Wildlife Research Center, Ohio Field Station, 6100 Columbus Avenue, Sandusky, OH 44870 http://www.aphis.usda.gov/wildlife_damage/nwrc/

Efficacy of Aircraft Landing Lights in Stimulating Avoidance Behavior in Birds - B. F. Blackwell and G. E. Bernhardt

Avian Visual System Configuration and Behavioural Response to Object Approach - B. F. Blackwell, E. Fernandez-Juricic, T. W. Seamans, and T. Dolan

2.4 Definitions

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.

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

RATED AVERAGE LABORATORY LIFE: Rated average laboratory life is the average life obtained when 50% of a statistically large group of the same lamps still survive in closely controlled life testing at their design voltage. Lamps are typically tested using 60 Hz AC voltage. DC operation of lamps may reduce lamp life on some lower current lamps. Rated average laboratory life is not necessarily the same as service life. Conditions such as mechanical shock, vibration, voltage fluctuations, and environmental extremes may result in shorter average attained life. Does not apply to LED based lamps as they use different methods to determine life (refer to ARP881).

HIGH INTENSITY DISCHARGE (HID or XENON): A light source using an electrical gas-discharge source which produces light by means of an electrical arc between two electrodes. The arc is contained within a quartz tube filled with a noble gas such as Xenon and a mixture of metallic salts. The salts are turned into a plasma by the arc and the particular mix of salts determines the emission spectrum of the lamp. HID lamps require a high voltage to create the arc, typically provided by an electronic ballast.

LIGHT EMITTING DIODE: A solid state light source using a semiconductor which emits light when excited by an electric current. Different semiconductor materials have different band gaps and produce very pure monochromatic light of different colors. The most common way of creating white light with an LED uses a blue diode covered with a yellow phosphor, but white light can also be created by combining several LED dies of different colors (i.e., red, green, and blue). LEDs require low voltages and a controlled current, which can be provided by a remote power supply or built into the light.

PAR: Parabolic Aluminized Reflector. Incandescent and halogen sealed beam lamps are often called PAR lamps, with a number following the PAR to indicate the diameter of the lamp. The number corresponds to the diameter in eighths of an inch. Hence, a PAR 36 lamp is 4.5 inches in diameter, and a PAR 64 lamp is 8 inches in diameter.

3. DETAILED RECOMMENDATIONS

3.1 Landing Lights

3.1.1 General Provisions

3.1.1.1 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 airplane's approach glide path or on the runway at night.

3.1.1.2 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 of the landing lights have the ability to be activated when the Landing gear and slats/flaps are retracted.

3.1.1.3 The federal aviation regulations (CFR Parts 23.1383, 25.1383, 27.1383, and 29.1383) contain the following general requirements for landing and taxi lights:

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. It provides enough light for night landing.

The traditional way to provide lights for landing and taxiing involves mounting high-intensity halogen sealed beam lamps in various locations on the aircraft. With the advent of High Intensity Discharge (HID) and Light Emitting Diode (LED) lighting, designers now have more freedom to design lighting with different beam patterns, emission spectra, lifetimes, and maintenance characteristics. Because sealed beams have been used successfully for many years, Tables 1 and 2 are provided as guidance for typical lighting installations. If newer technology lighting will be used on an aircraft, the light pattern produced by the halogen technology can be used as a basis of comparison.

Table 1 - Lamps for landing service

NOTE: The lamps listed below represent typical industry standards for this type of installation. The peak intensity and beam spread values in the table are derived from the manufacturer's data sheets. Actual measured values often vary significantly from the data sheet numbers.

Lamp No[1].	Watts	Volts	Bulb	Rated Ave. Lab. Life (hours)	Initial Peak Intensity on Centerline (cd)[2]	Nominal Horizontal Beam Spread to 10% of Peak Intensity (deg)[3]	Nominal Vertical Beam Spread to 10% of Peak Intensity (deg)[3]	Category See Section 1
4509	100	13	PAR-36	25	110000	12	6	a
Q4509	100	13	PAR-36	100	140000	3	3	a
4591	100	28	PAR-36	25	90000	12	6	a
4537	100	13	PAR-46	25	200000	11	6	a
4313	250	13	PAR-36	25	140000	16	7	a,b
4522	250	13	PAR-46	25	290000	12	10	a,b
4553	250	28	PAR-46	25	300000	11	12	a
4552	250	28	PAR-46	25	500000	7	8	b
4581	450	28	PAR-46	10	400000	13	14	b,e,f,
4559	600	28	PAR-64	25	600000	11	12	c,d,f
Q4559	600	28	PAR-64	100	600000	12	8	c,d,f
Q4559X	600	28	PAR-64	100	765000	11	7-1/2	c,d,f,
4556	1000	28	PAR-64	25	700000	12	13	c,d
Q4681	450	28	PAR-46	50	310000	15	9	c,d
4557 Land.	1000	28	PAR-64	25	540000	11	15	c,d
Taxi.	400	28	PAR-64	100	100000	25	11	c,d

NOTES:
1. The Lamp numbers refer to ANSI specifications and are not specific to any one manufacturer.
2. Due to manufacturing variations, the peak intensity may not be precisely on the axis of the lamp.
3. This is the full width from 10% of the peak on one side to 10% of the peak on the other side of the beam center (see Figure 4).

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

Table 2 - Recommended number of landing lights for different category airplanes

Airplane Categories	Minimum Number of Landing Lights
Single engine personal and/or liaison type (category a)	2
Light twin engine (category b)	2
Large multiengine propeller (category c)	3
Large multiengine jet propulsion (category d)	4
Military high-performance fighter and attack (category e)	2
Helicopter (category f):	
Retractable landing light	1
Searchlight (may be used as landing light)	1

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

3.1.1.4 The landing lights should provide sufficient illumination of the runway for night landings. As a design objective, 21.5 lux (2 ft-c) minimum at 122 m (400 feet) in front of the pilot at touchdown attitude and 5.4 lux (0.5 ft-c) minimum at 91 m (300 feet) in front of the pilot during ground roll should be provided (see Figures 1 and 2). Lux (ft-c) levels are measured normal to the light beam. Aircraft-specific details should be considered when designing a landing light system. Although only a single illuminance value is mentioned, the purpose of a landing light system is to provide sufficient illumination over the entire runway surface out to a sufficient distance in front of the aircraft. Calculating or measuring an average illuminance over a desired illuminated area is one way of comparing performance between landing light systems (see Appendix C).

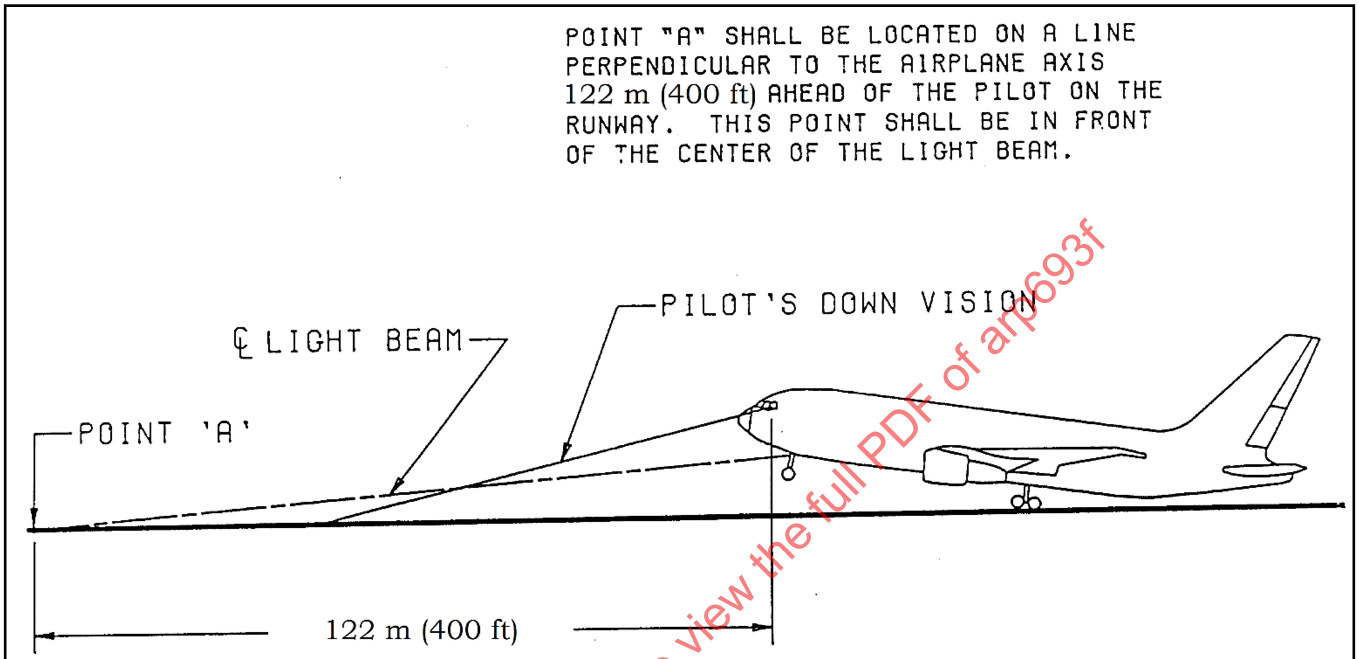

Figure 1 - Landing light at touch down attitude

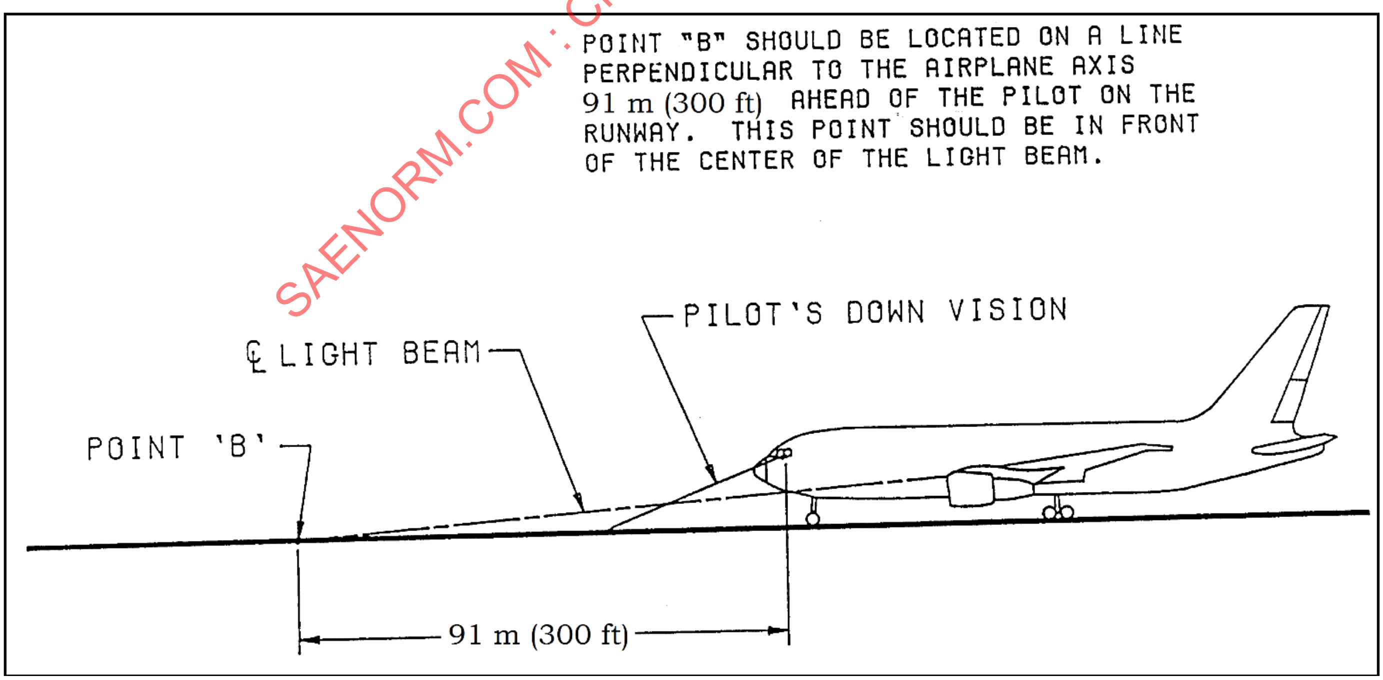

Figure 2 - Landing light at ground roll attitude

3.1.1.5 It should be noted that normal approach attitudes vary between particular airplanes, depending upon speed, flap conditions, etc. In most cases, the landing attitude and taxiing attitude of the airplane are not the same; however, the landing lights should accommodate adequate light coverage for final approach, touchdown, and ground roll illumination. For some airplanes, it may be necessary to re-aim the landing lights or to use multiple landing lights aimed to cover the various aircraft attitudes.

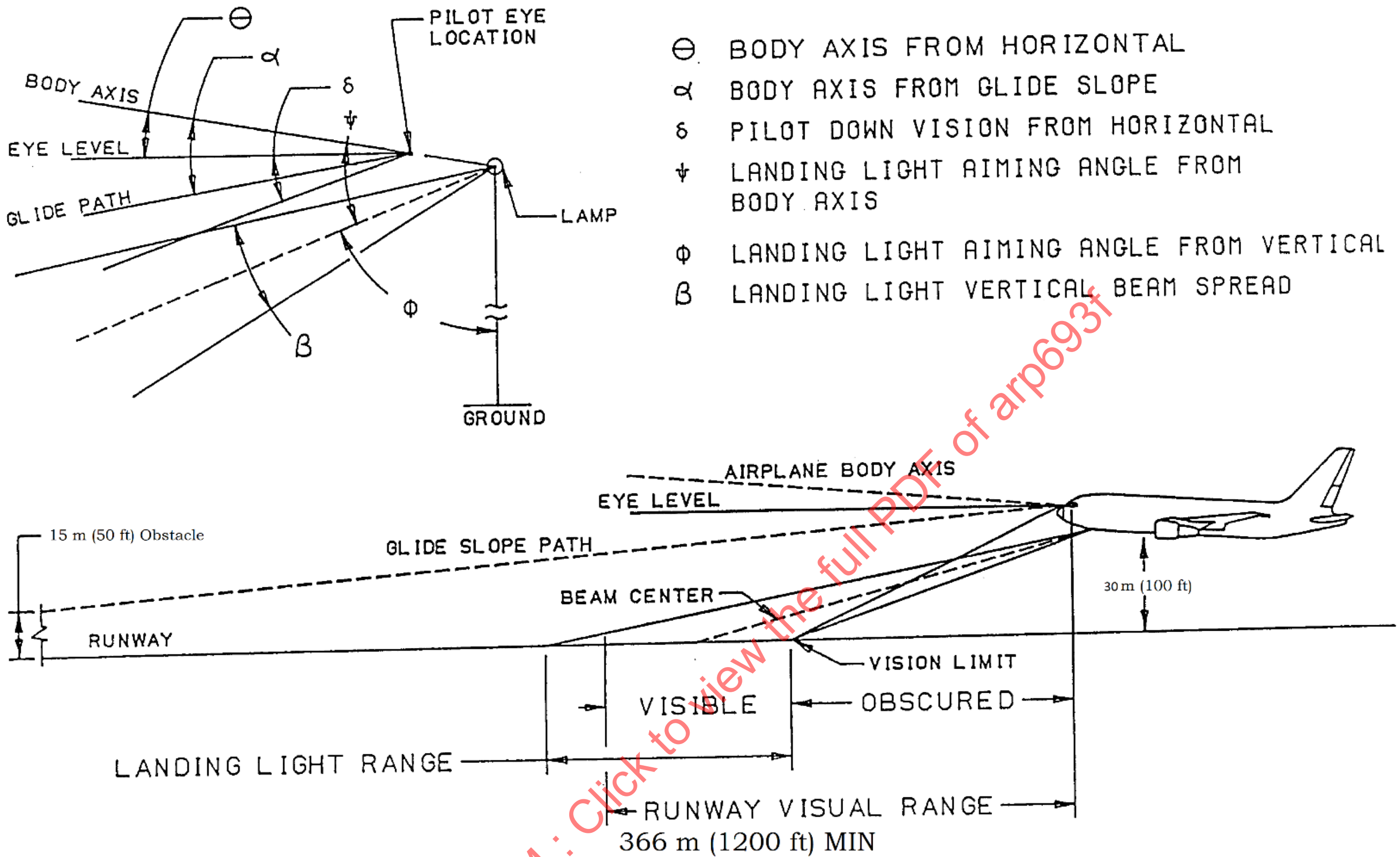

Figure 3 - Landing light at approach attitude

3.1.1.6 While the performance of the landing lights as a system needs to be considered by the aircraft designer, the system is often comprised of multiple lights that each contribute a portion of the final beam. The performance of those lights in any given system will depend upon mounting location, aim angle, and possible blockage caused by aircraft structures. This is why the test points in 3.1.1.4 are measured directly in front of each individual light instead of on the aircraft centerline. Since the illuminance produced by a light depends upon the distance to the point being measured, it is impractical to design or test a light based on illuminance measurements, especially if it is intended for use in multiple installations. For this reason, it is recommended that individual lights are specified and tested using luminous intensity profiles or an intensity matrix.

As shown in Table 1, sealed beam lights have typically been specified using a peak intensity and the vertical and horizontal beam spread out to 10% of the peak. This method of specification may not be adequate, however, as illustrated in Figure 4.

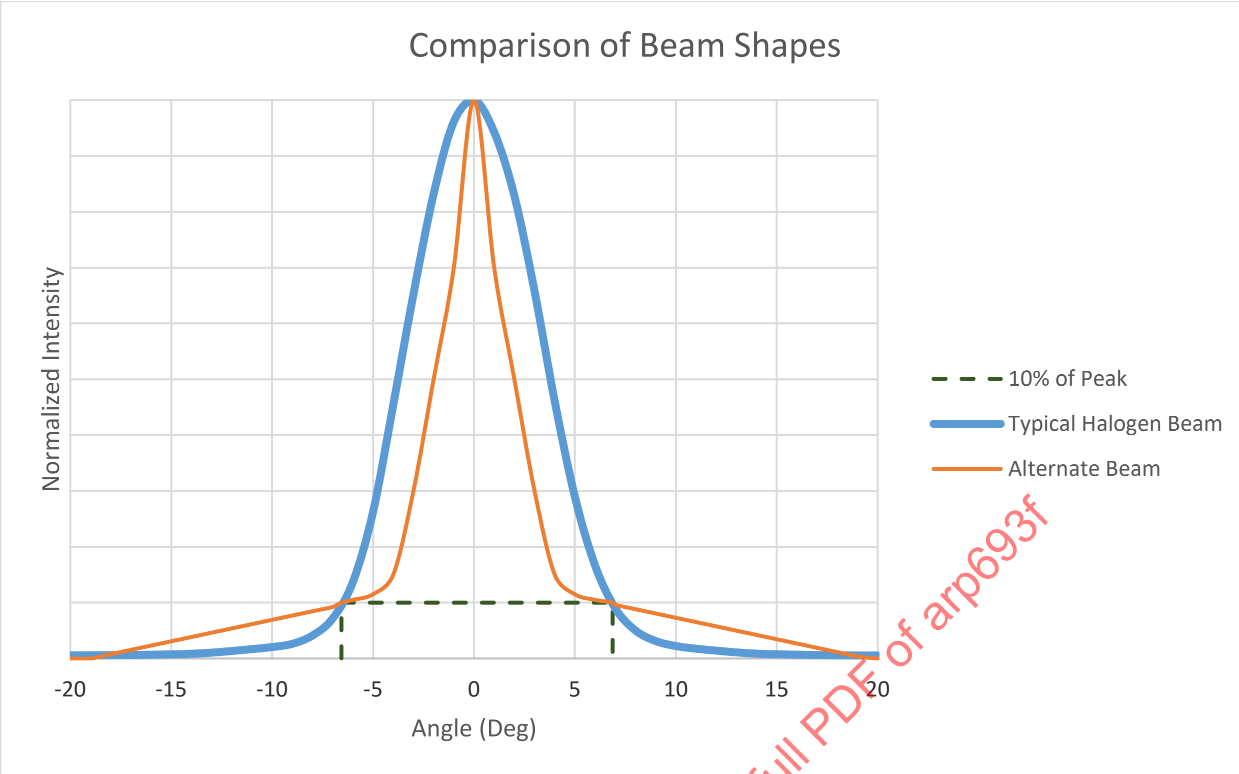

Figure 4 - Comparison of beam shapes

Both of the plots shown in Figure 4 have the same peak intensity and the same beam width at 10% of the peak, but the alternate beam would create a much narrower illuminated area on the runway. In order to avoid situations like this, a more comprehensive specification should be written. Commercially available software makes it possible to simulate the entire beam distribution for a light, enabling more detailed specifications than were possible in the past.

3.1.1.7 Sealed Beam Lights

The most common technology used for landing lights is the sealed beam lamp. Although widely available and inexpensive, the designer needs to be aware of the characteristics of these bulbs. Following are some traits that should be considered.

- Incandescent sealed beams slowly blacken with use, significantly reducing light output with time. Halogen sealed beams do not blacken so their light output degrades at a slower rate.

- As can be seen in Table 1, sealed beam bulbs have relatively short lifetimes (25 to 100 hours). This leads to higher maintenance costs and downtime.

- Sealed beam bulbs draw large currents, which often causes a voltage drop between aircraft power and the lamp. Lower voltages at the bulb result in lower photometric performance.

- The resistance of a tungsten filament when cold is significantly lower than it is when hot, leading to high inrush currents when the bulb is switched on. These current surges can cause premature bulb failure. Inrush current limiting circuits are one way to prevent these failures. Another option is to maintain a low current through the filament even in the off state to keep it warm.

3.1.1.8 High Intensity Discharge (HID) Lights

HID lights are sometimes used as they have some advantages over halogen lights. The following traits of HID lights are relevant:

- They have no filament to break and are more able to withstand high vibration environments.
- They have a longer lifetime than halogen bulbs (3000 to 5000 hours).
- They are more efficient and use less power.
- They require high voltages to start and maintain the arc, so a high voltage ballast is required.
- They have different spectral characteristics from halogen bulbs (see 3.1.1.11).

3.1.1.9 HID lights should be capable of hot re-strike in any ground or flight condition.

3.1.1.10 Light Emitting Diode (LED) Lights

LED lights are becoming popular as landing lights. Detailed recommendations for LED landing, taxi, and turnoff lights can be found in ARP6402. A few general considerations follow:

- LED lights have extremely long lifetimes (10000 to 50000 hours). Refer to ARP6402 paragraph 4.3 for further clarification on the definition of LED life.
- They are very efficient.
- They require an electronic power supply to control the voltage and current through the LEDs.
- They can be packaged in many different shapes and volumes.
- They are sensitive to heat and typically require a heat sink or other cooling method.

3.1.1.11 Color to be White

White light is a combination of all light colors, but differences in how those colors are created and combined create differences in the spectral content of a light. Figure 5 compares the typical spectra for three kinds of lights—halogen, HID, and LED. While all these lights will appear white, the different spectra can have an effect on visibility and color discrimination. While high color rendering capability is not necessary for basic obstacle detection, aircraft manufacturers should perform an assessment to determine adequate color discrimination for runway and taxiway signs as well as color contrasts between the pavement and surrounding environment for the proper orientation of the aircraft on runways and taxiways.

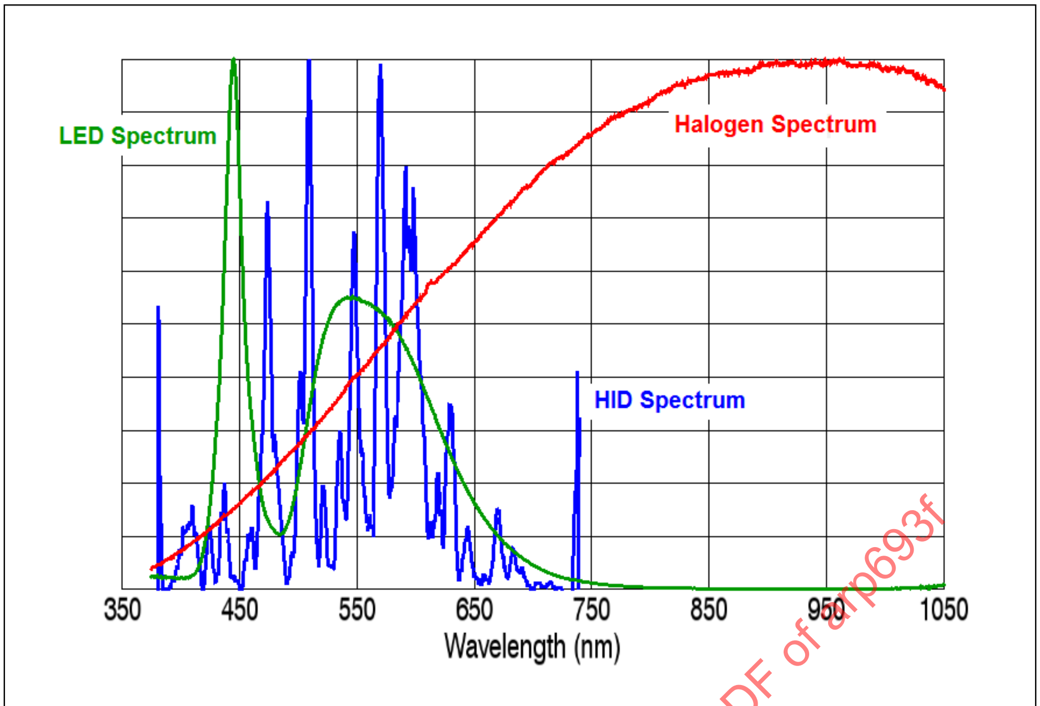

Figure 5 - Spectral content of typical sources for landing lights

3.1.1.12 Landing Light Locations

Many factors must be accounted for when deciding where to locate the landing lights. Retractable landing lights or lights located on the landing gear provide physical protection of the landing lights when not in use. Locating lights farther from the pilot's line of sight may reduce glare (refer to *Forward Vehicular Lighting and Inclement Weather Conditions*). When considering landing light locations, the shadowing effects of aircraft structure should be considered. Optical simulations of the illuminance pattern produced by the landing lights can be used to compare different mounting configurations. Typical locations of lights are listed below:

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

3.1.2 Aiming and Illuminated Areas

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

a. Prior to touchdown, the pilot will start using the lights as he/she initiates the flare. The landing light should be designed to provide illumination somewhat ahead of the pilot's vision limit, and along the glide slope (see Figure 3).

b. Before the point of touchdown is reached, the airplane 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 feet) away from the pilot (see Figure 1).

c. After touchdown, the nose wheel gradually drops to the ground and the airplane assumes a ground roll attitude. At this point, it is desirable to provide illumination of the runway centerline at least 91 m (300 feet) away from the pilot (see Figure 2).

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

3.1.3 Installation and Lamp Beam Adjustment

For sealed beam lamps, three mounting lugs on the back of the lamp ensure proper alignment of the light with the mounting bracket or fixture. Other types of lamps may use different mounting provisions. Given the importance of having the landing lights properly aimed, it may be necessary to provide features that allow for aim adjustments to account for manufacturing variations in the fixture or the lamps.

In certain mounting locations, aircraft structures can block light from the landing light. When determining the mounting location and evaluating the illuminance pattern of a landing light, any blockage, whether temporary or permanent, needs to be considered. Examples of possible blockages are: landing gear doors, propellers, antennae, wing root lens openings, flap track fairings, etc.

It is advisable to provide a means to secure the conductors that supply power to sealed beam lamps. In the event of failure of a sealed beam lamp, physical restraint of the lamp is lost and unsecured wires or the inner halogen capsule can come into contact with nearby surfaces, causing short circuits or thermal damage.

3.1.4 Controls

3.1.4.1 Each landing light should be controlled by a separate switch [reference Part § 25.1383 (b) "Except when one switch is used for the lights of a multiple light installation at one location, there must be a separate switch for each light."] unless an Equivalent Safety Finding has been approved for a single switch installation. The most common reason for separate switching is to prevent propeller flicker.

3.1.4.2 One switch may be used for the lights of a multiple light installation if these lights are all installed at one location.

3.1.4.3 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 for controlling the motor drive circuit. This switch may allow aiming control at any position between the fully extended and the fully retracted positions.

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

3.1.4.5 An automatic control switch should be provided to turn off the landing lights when they are installed in the wheel well and when the landing gear is retracted.

3.1.4.6 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 their high electricity consumption and to reduce the possible heating of other components on the aircraft by the lamp. An indication shall be provided to the flight crew that this function is activated. This function may be automated by sensing the weight on the landing gear or similar indicators.

While incandescent or halogen lights can be dimmed by simply lowering the voltage supplied to the lamp, LED and HID lights may require alternate methods of dimming due to their electronic power supplies. Because of their lower power consumption, dimming may not be necessary or may be applied in different situations (such as high temperature operation.)

3.1.4.7 Consideration should be given to provide redundant lighting control circuits and lamps to minimize the consequences of failures and improve dispatch reliability.

3.1.4.8 Rotary wing aircraft sometimes use a controllable searchlight as a landing light. In such cases, the controllable searchlight should be installed so that when the light is fully stowed, the plane of the lamp mounting ring will be horizontal 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.

3.2 Taxi Lights

3.2.1 General Provisions

3.2.1.1 Taxi lights are not required by the FAA. When present, they are used to provide illumination when the aircraft is maneuvered on the ground at night. They typically have a wide pattern to illuminate the full width of the runway. Because sealed beams have been used in these applications successfully for many years, Table 3 is provided as guidance for typical lighting installations. If newer technology lighting will be used on an aircraft, the light pattern produced by the sealed beam technology can be used as a basis of comparison.

Table 3 - Lamps for taxiing service

NOTE: The lamps listed below represent typical industry standards for this type of installation. However, other lamps with similar characteristics (input voltage, environmental, dynamic and luminous intensity) may be used with comparable results.

Lamp No.	Watts	Volts	Bulb	Rated Ave. Lab. Life (hours)	Initial Peak Intensity on Centerline	Nominal Horizontal Beam Spread to 10% of Peak Intensity (deg)	Nominal Vertical Beam Spread to 10% of Peak Intensity (deg)	Category (See Section 1)
4503	40	14	PAR-36	400	11000	--	--	a
4502	50	28	PAR-36	400	10000	40	7	a
4570	150	28	PAR-46	300	32000	50	9	b,c
4551	250	28	PAR-46	25	75000	50	10	c,d,e,
Q4631	250	13	PAR-36	500	80000	13	12	c,d
4554	450	28	PAR-46	25	90000	50	16	c,e
Q4554	450	28	PAR-46	100	65000	50	11	c,d
4557 Land.	1000	28	PAR-64	25	540000	11	15	c,d
Taxi.	400	28	PAR-64	100	100000	25	11	c,d

3.2.1.2 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 lights should provide a minimum illumination on each side of the centerline of the aircraft to 3 m (10 feet) outboard from each wingtip. The illuminated area may be narrower if supplemented by runway turnoff lights.

3.2.1.3 As a design objective 54 lux (5 ft-c) minimum at 30.5 m (100 feet) in front of the pilot should be provided for the taxiing light (see Figure 6). Lux (ft-c) levels are measured normal to the light beam. Although only a single illuminance value is mentioned, the objective of the taxi light is to illuminate the entire runway or taxiway if used alone, or the central portion of the runway or taxiway if used in conjunction with runway turnoff lights. Calculating or measuring an average illuminance over the desired illuminated area is one way of comparing performance between taxi light systems (see Appendix C). When a runway turnoff light is present, there should not be a non-illuminated gap visible between the taxi and turnoff light lit areas.

3.2.1.4 On small airplanes taxi lights may not be installed. If installed, a single lamp in the nose or on the nose wheel strut is usually sufficient.

3.2.1.5 Typical Locations of Taxi Lights

1. Nose wheel gear (steerable)

2. Nose landing gear strut

3. Wing/body strake (wing root)

4. Each side of fuselage (ahead of wing)

3.2.2 Aiming

It is recommended that the taxiing light on the nosewheel be aimed in the direction of travel with the center of the beam horizontal. When runway turnoff lights are not present, it is desirable to install the taxi light on the nosewheel's movable strut so that the light will turn laterally with the nosewheel strut.

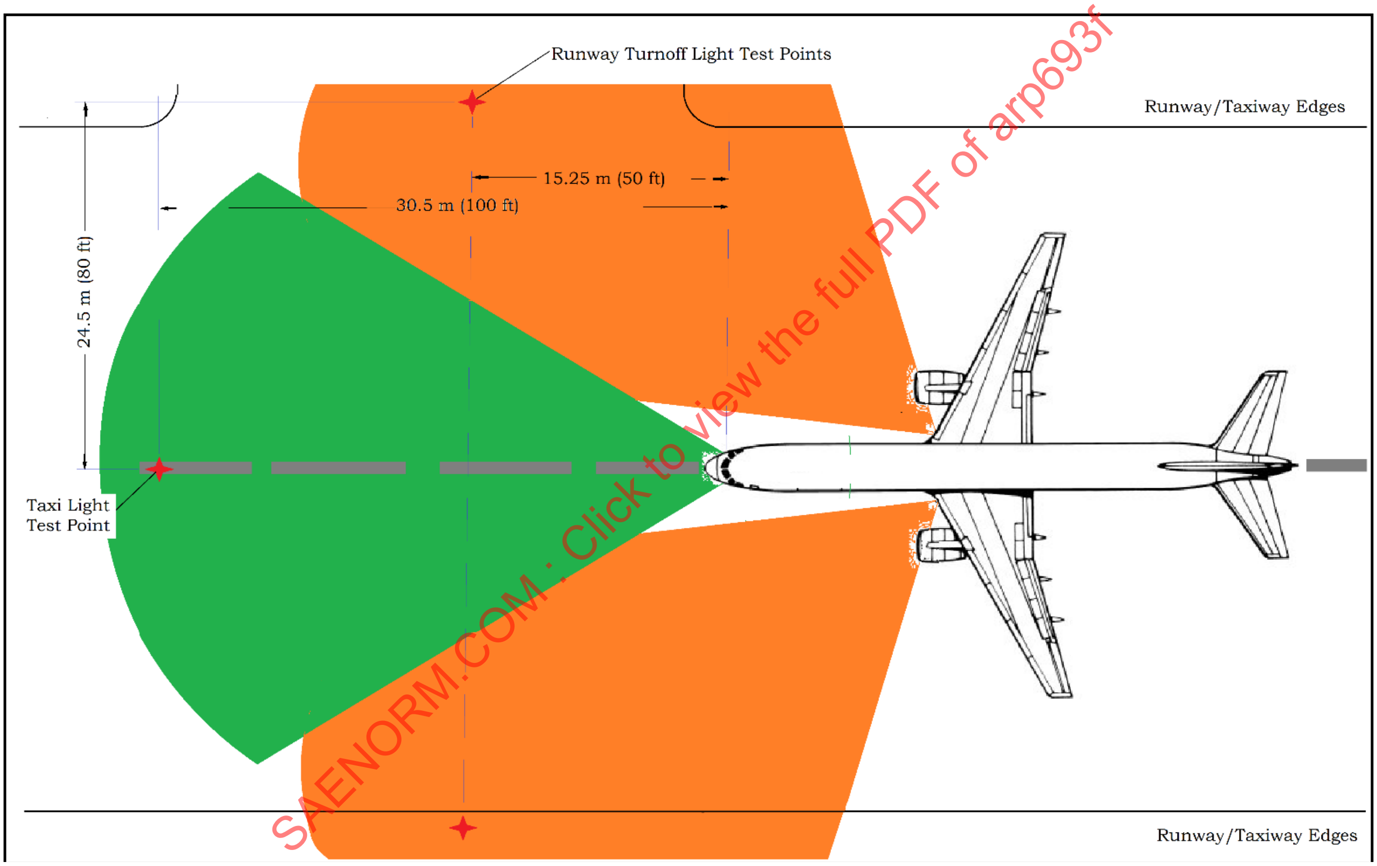

Figure 6 - Taxi and runway turn off light illumination areas

3.2.3 Installation and Lamp Beam Adjustment

It is recommended that each light fixture design contain provisions to allow the lamp to be adjusted, ensuring that the correct horizontal and vertical beam pattern orientation can be achieved.

3.2.4 Control

The taxi light system should be capable of being operated independently (i.e., from a separate switch) from the landing light system. In addition, each taxi light may be controlled by a separate switch if needed for propeller flicker or fog/haze conditions.

3.3 Runway Turnoff Lights

3.3.1 General Provisions

Runway turnoff lights are used to augment the taxi lights on large multiengine jet aircraft when taxiing. They are typically aimed to the sides of the runway to illuminate runway turnoff areas. If using sealed beam technology, see Table 3 for examples of commonly used sealed beam lamps. The landing lights are normally switched off while taxiing to conserve the lamps and to avoid blinding oncoming traffic.

3.3.1.1 As a design objective, 21.5 lux (2 ft-c) minimum at 15.25 m (50 feet) in front and 24.5 m (80 feet) outboard of the pilot should be provided for the runway turnoff light (see Figure 6). Once again, only a single illuminance value is mentioned, but the intent is to provide sufficient illumination of the sides of the runway or taxiway beyond the area illuminated by the taxi lights. Calculating or measuring an average illuminance over the desired illuminated area is one way of comparing performance between taxi and runway turnoff light systems (see Appendix C).

3.3.1.2 On large airplanes at least two runway turnoff lights should be required. The combination of both runway turnoff lights and taxiing lights provides the most desirable coverage, even in low visibility conditions.

3.3.2 Aiming

It is recommended that the runway turnoff lights be aimed outboard at an angle that will illuminate the sides of the runway or taxiway and any runway turnoff areas. Since the runway turnoff lights are typically used in conjunction with taxi lights, it is recommended that the runway turnoff lights should be aimed so that there are no dark areas between the taxi light beam and the runway turnoff light beam.

3.4 Recognition Lights

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

3.5 Installation Design

3.5.1 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 for both ground and flight operations. The requirements of RTCA Document DO-160 may be used except where anticipated conditions are more severe.

3.5.2 Each installation shall conform to appropriate EMI requirements found in RTCA Document DO-160.

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

3.5.4 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 25.981-1 provides guidelines for components in close proximity to fuel tanks or tank surfaces.

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

3.5.6 Maintainability and Re-Lamping

Special consideration should be given to the design and installation of the lights so that the lamps can be changed within a minimum amount of time. They should be replaceable by using conventional tools without readjustment or re-aiming the lights. For retractable landing lights, relamping should be accomplished in either the retracted position or extended position. Because of the expected long lifetimes of LED lights, re-lamping will not be as frequent as with sealed beam lights. Thus, longer re-lamping times may be more acceptable for LED light installations.

3.5.7 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 to no more than 60 degrees to alleviate light distortion and minimize loss of illumination.

3.5.8 It is recommended that the voltage drop from the power source to the lamp be minimized to maintain light loss of no more than 15%.

3.5.9 Location Considerations

The light fixtures should be designed and installed such that they will not induce sensing errors or other negative effects.

3.5.10 Operation Parameters (Retractable Landing Light)

3.5.10.1 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.

3.5.10.2 The light should have an aerodynamic 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 once the overload is removed the light should operate normally.

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

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

3.5.10.5 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 also allow the retraction of the light in case of a failure of the normal operation mechanism preventing possible buffeting and early structure fatigue caused by extension at supersonic speeds.

3.5.10.6 Under icing conditions the motor should not stall and should extend and retract the light properly.

3.5.10.7 The light should be designed to minimize aerodynamic drag.

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

3.5.10.9 Retractable light components must be designed for the external environment as well as the loads and flexing that will occur with extension and retraction.

3.5.11 Safety Practice

The safety and performance of the lighting system in all environments is dependent on the effectiveness of the electrical bonding and grounding system. The impact of the designer's approach on the design should be evaluated beginning with the early design configurations to ensure that system performance and safety are "designed in," rather than added later which could result in fixes that add unnecessary weight, substandard compromises or added costs.

3.5.11.1 Current Return Ground

A design objective of exterior lighting equipment and their installations 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 permit protection by the aircraft's input power circuit breaker. The ground lead size should be at least equal to the power input lead size.

3.5.11.2 Explosion Hazard Grounds

In fire prevention and flammable leakage zones, an applicable dual ground termination is required. Dual ground implies that separate grounding methods such as faying surface bond and internal case ground are provided, each independently meeting the resistance requirements of Figure 7. In most cases, a case ground through the connector will not meet these requirements and an external jumper is required. Electromechanical compatibility must be considered when selecting jumpers, terminals, and the treatment of faying surface(s).

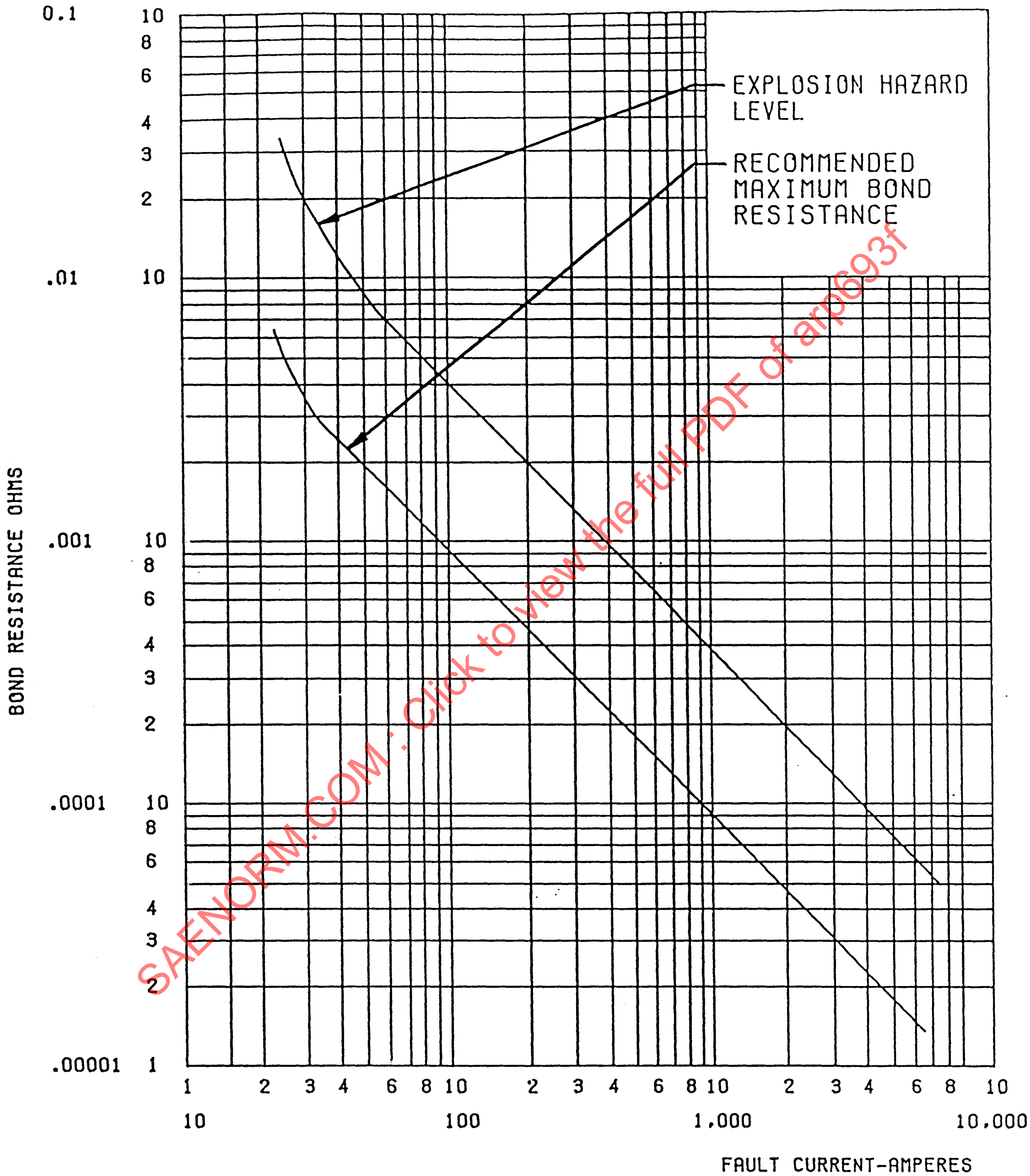

Figure 7 - Recommended maximum bonding resistance values in explosion hazard areas

3.5.11.3 Personnel Protection Grounds

Consideration should be given to possible shock under conditions where personnel would be standing in water or where the equipment would be exposed to large quantities of water.

Equipment operating above 1.25 VAC or 5 VDC and subjected to these moisture conditions require a single case ground unless they are completely contained in nonconductive housings. Under maximum fault current conditions, the voltage from case to ground should not exceed these values. Equipment operating on 115 VAC should have two ground paths, each limiting the voltage from case to structure to 1.25 VAC under maximum fault current conditions.

For all other areas, equipment operating above 10 VAC and 30 VDC should contain a jumper or faying surface ground unless they are completely contained in nonconductive housings.

3.5.12 Other Considerations

3.5.12.1 It is desirable to provide drains/vents as needed to drain water out of the fixture due to moisture condensation and to maintain minimum pressure differential between the light cavity and the atmosphere if applicable.

3.5.12.2 Lens fairings or clamping means should be designed to prevent lens breakage or cracking due to mechanical or thermal stress.

3.5.12.3 Lights with aim adjustment mechanisms should have mechanical adjustments with positive locking for fine light aiming. Primary aiming should be designed into the light housing. The adjustment envelope should be per the procurement document when appropriate.

3.5.12.4 Airplane structure cutout to accommodate the light installation should be kept to a minimum.

4. NOTES

4.1 Revision Indicator

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

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