AIRPORT STANDARDS DIRECTIVE 501
[ASD 501]

VISUAL AIDS FOR NAVIGATION -
AERONAUTICAL GROUND LIGHTS,
ELECTRICAL SYSTEM & MAINTENANCE
This Airport Standards Directive is published and enforced by the Director General of Civil Aviation Malaysia under the provision of the Section 24O Civil Aviation Act 1969 (Act3) – Amendment 2006.
## AMENDMENT RECORD

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INTRODUCTION

1. In exercise of the powers conferred by regulation 12 (c) of the Civil Aviation (Aerodrome Operations) Regulations 2016, the Director General makes this Airport Standards Directive.


3. Aeronautical Ground Lighting (AGL) is the generic term used to describe the various lighting systems that are provided on an aerodrome for the guidance of pilots operating aircraft both at night and in low visibility conditions. AGL systems vary in complexity from the basic patterns found at small aerodromes in support of flying training operations, to the more advanced systems used in support of "all-weather operations", usually associated with an Instrument Landing System (ILS). To ensure the regularity and safety of aviation, it is necessary that aerodrome electrical system have high integrity and reliability. It is considered that the probability of failure of well designed and maintained electrical system at a critical moment is extremely low.

4. This Directive outlines the application of provisions under the Act in the form of rules, instructions and practices pertaining to the aeronautical ground lights to which aerodrome operator shall be informed and obliged to comply.

5. This Directive has been written in general terms. Specific advice could be obtained from the Authority at:

   Department of Civil Aviation
   Airport Standards Division
   Level 1 Block Podium B
   No. 27 Persiaran Perdana
   Precinct 4,
   62618 PUTRAJAYA
   Phone: 03-88714000
   Fax : 03-88714335
OBJECTIVE

6. This Directive specifies the type, location and characteristics of aeronautical ground lights, electrical system and maintenance of visual aid to be used in an aerodrome that shall be complied by all aerodrome operators. This Directive also to aid in the safe of aircraft. Therefore, the highest standards of electrical design and maintenance are required. Once a system has been installed, its usefulness is dependent on its services ability which turn depend upon the effectiveness of the maintenance work carried out.

APPLICABILITY

7. The specification in this Directive shall apply to all aerodromes open to public transport aircraft.

AUTHORITY

8. The Authority referred to this Directive is the Director General of Civil Aviation.

VISUAL AIDS FOR NAVIGATION

9. Lights

9.1 General

Lights which may endanger the safety of aircraft

9.1.1 A non-aeronautical ground light near an aerodrome which might endanger the safety of aircraft shall be extinguished, screened or otherwise modified so as to eliminate the source of danger.
Laser emissions which may endanger the safety of aircraft

9.1.2 To protect the safety of aircraft against the hazardous effects of laser emitters, the following protected zones should be established around aerodromes –

(a) a laser-beam free flight zone (LFFZ)
(b) a laser-beam critical flight zone (LCFZ)
(c) a laser-beam sensitive flight zone (LSFZ).

Note 1.—Appendix A, Figures A1-1, A1-2 and A1-3 may be used to determine the exposure levels and distances that adequately protect flight operations.

Note 2.—The restrictions on the use of laser beams in the three protected flight zones, LFFZ, LCFZ and LSFZ, refer to visible laser beams only. Laser emitters operated by the authorities in a manner compatible with flight safety are excluded. In all navigable airspace, the irradiance level of any laser beam, visible or invisible, is expected to be less than or equal to the maximum permissible exposure (MPE) unless such emission has been notified to the authority and permission obtained.

Note 3.—The protected flight zones are established in order to mitigate the risk of operating laser emitters in the vicinity of aerodromes.

Note 4.—Further guidance on how to protect flight operations from the hazardous effects of laser emitters is contained in the ICAO Manual on Laser Emitters and Flight Safety (Doc 9815).

Note 5.—See also ICAO Annex 11 — Air Traffic Services, Chapter 2.

Lights which may cause confusion

9.1.3 A non-aeronautical ground light which, by reason of its intensity, configuration or color, might prevent, or cause confusion in, the clear interpretation of aeronautical ground lights should be extinguished, screened or otherwise modified so as to eliminate such a possibility. In particular, attention should be directed to a non-aeronautical ground light visible from the air within the areas described hereunder:
(a) Instrument runway - code number 4: within the areas before the threshold and beyond the end of the runway extending at least 4,500 m in length from the threshold and runway end and 750 m either side of the extended runway centre line in width.

(b) Instrument runway - code number 2 or 3: as in (a), except that the length should be at least 3,000 m.

(c) Instrument runway - code number 1; and non-instrument runway: within the approach area.

**Aeronautical ground lights which may cause confusion to mariners**

Note.—In the case of aeronautical ground lights near navigable waters, consideration needs to be given to ensuring that the lights do not cause confusion to mariners. Refer in Appendix A, Figure A1-1, A1-2 and A1-3.

**Light fixtures and supporting structures**

Note.—See ICAO Anex 14 Volume 1 Paragraph 9.9 for information regarding siting of equipment and installations on operational areas, and the Aerodrome Design Manual (Doc 9157), Part 6, for guidance on frangibility of light fixtures and supporting structures.

**Elevated approach lights**

9.1.4 Elevated approach lights and their supporting structures shall be frangible except that, in that portion of the approach lighting system beyond 300 m from the threshold:

(a) where the height of a supporting structure exceeds 12 m, the frangibility requirement shall apply to the top 12 m only; and

(b) where a supporting structure is surrounded by non-frangible objects, only that part of the structure that extends above the surrounding objects shall be frangible.
9.1.5 When an approach light fixture or supporting structure is not in itself sufficiently conspicuous, it shall be suitably marked.

**Elevated lights**

9.1.6 Elevated runway, stopway and taxiway lights shall be frangible. Their height shall be sufficiently low to preserve clearance for propellers and for the engine pods of jet aircraft.

**Surface lights**

9.1.7 Light fixtures inset in the surface of runways, stopways, taxiways and aprons shall be so designed and fitted as to withstand being run over by the wheels of an aircraft without damage either to the aircraft or to the lights themselves.

9.1.8 The temperature produced by conduction or radiation at the interface between an installed inset light and an aircraft tire should not exceed 160°C during a 10-minute period of exposure.

*Note.*—Guidance on measuring the temperature of inset lights is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 4.

**Light intensity and control**

*Note.* — In dusk or poor visibility conditions by day, lighting can be more effective than marking. For lights to be effective in such conditions or in poor visibility by night, they must be of adequate intensity. To obtain the required intensity, it will usually be necessary to make the light directional, in which case the arcs over which the light shows will have to be adequate and so orientated as to meet the operational requirements. The runway lighting system will have to be considered as a whole, to ensure that the relative light intensities are suitably matched to the same end. (See Attachment 1, Section 1, and the ICAO Aerodrome Design Manual (Doc 9157), Part 4).
9.1.9 The intensity of runway lighting shall be adequate for the minimum conditions of visibility and ambient light in which use of the runway is intended, and compatible with that of the nearest section of the approach lighting system when provided.

Note.—While the lights of an approach lighting system may be of higher intensity than the runway lighting, it is good practice to avoid abrupt changes in intensity as these could give a pilot a false impression that the visibility is changing during approach.

9.1.10 Where a high-intensity lighting system is provided, a suitable intensity control shall be incorporated to allow for adjustment of the light intensity to meet the prevailing conditions. Separate intensity controls or other suitable methods shall be provided to ensure that the following systems, when installed, can be operated at compatible intensities:

(a) approach lighting system;
(b) runway edge lights;
(c) runway threshold lights;
(d) runway end lights;
(e) runway centre line lights;
(f) runway touchdown zone lights; and
(g) taxiway centre line lights.

9.1.11 On the perimeter of and within the ellipse defining the main beam in Appendix C, Figures C1-1 to C1-10, the maximum light intensity value shall not be greater than three times the minimum light intensity value measured in accordance with Appendix C, collective notes for Figures C1-1 to C1-11, Note 2.

9.1.12 On the perimeter of and within the rectangle defining the main beam in Appendix C, Figures C1-12 to C1-20, the maximum light intensity value shall not be greater than three times the minimum light intensity value measured in accordance with Appendix C, collective notes for Figures C1-12 to C1-21, Note 2.
9.2 Emergency lighting

Application

9.2.1 At an aerodrome provided with runway lighting and without a secondary power supply, sufficient emergency lights should be conveniently available for installation on at least the primary runway in the event of failure of the normal lighting system.

Note. — Emergency lighting may also be useful to mark obstacles or delineate taxiways and apron areas.

Location

9.2.2 When installed on a runway the emergency lights should, as a minimum, conform to the configuration required for a non-instrument runway.

Characteristics

9.2.3 The colour of the emergency lights should conform to the colour requirements for runway lighting, except that, where the provision of coloured lights at the threshold and the runway end is not practicable, all lights may be variable white or as close to variable white as practicable.

9.3 Aeronautical beacons

Application

9.3.1 Where operationally necessary an aerodrome beacon or an identification beacon shall be provided at each aerodrome intended for use at night.
9.3.2 The operational requirement shall be determined having regard to the requirements of the air traffic using the aerodrome, the conspicuity of the aerodrome features in relation to its surroundings and the installation of other visual and non-visual aids useful in locating the aerodrome.

Aerodrome beacon

9.3.3 An aerodrome beacon shall be provided at an aerodrome intended for use at night if one or more of the following conditions exist -

(a) aircraft navigate predominantly by visual means;

(b) reduced visibilities are frequent; or

(c) it is difficult to locate the aerodrome from the air due to surrounding lights or terrain.

Location

9.3.4 The aerodrome beacon shall be located on or adjacent to the aerodrome in an area of low ambient background lighting.

9.3.5 The location of the beacon should be such that the beacon is not shielded by objects in significant directions and does not dazzle a pilot approaching to land.

Characteristics

9.3.6 The aerodrome beacon shall show either coloured flashes alternating with white flashes, or white flashes only. The frequency of total flashes shall be from 20 to 30 per minute. Where used, the coloured flashes emitted by beacons at land aerodromes shall be green, and coloured flashes emitted by beacons at water aerodromes shall be yellow. In the case of a combined water and land aerodrome, coloured flashes, if used, shall have the colour characteristics of whichever section of the aerodrome is designated as the principal facility.
9.3.7 The light from the beacon shall show at all angles of azimuth. The vertical light distribution shall extend upwards from an elevation of not more than 1° to an elevation determined by the appropriate authority to be sufficient to provide guidance at the maximum elevation at which the beacon is intended to be used, and the effective intensity of the flash shall be not less than 2 000 cd.

Note.— At locations where a high ambient background lighting level cannot be avoided, the effective intensity of the flash may be required to be increased by a factor up to a value of 10.

Identification beacon

Application

9.3.8 An identification beacon shall be provided at an aerodrome which is intended for use at night and cannot be easily identified from the air by other means.

Location

9.3.9 The identification beacon shall be located on the aerodrome in an area of low ambient background lighting.

9.3.10 The location of the beacon should be such that the beacon is not shielded by objects in significant directions and does not dazzle a pilot approaching to land.

Characteristics

9.3.11 An identification beacon at a land aerodrome shall show at all angles of azimuth. The vertical light distribution shall extend upwards from an elevation of not more than 1° to an elevation determined by the appropriate authority to be sufficient to provide guidance at the maximum elevation at which the beacon is intended to be used, and the effective intensity of the flash shall be not less than 2 000 cd.
Note. — At locations where a high ambient background lighting level cannot be avoided, the effective intensity of the flash may be required to be increased by a factor up to a value of 10.

9.3.12 An identification beacon shall show flashing-green at a land aerodrome and flashing-yellow at a water aerodrome.

9.3.13 The identification characters shall be transmitted in the International Morse Code.

9.3.14 The speed of transmission should be between six and eight words per minute, the corresponding range of duration of the Morse dots being from 0.15 to 0.2 seconds per dot.

9.4 Approach lighting systems

Application

9.4.1 Application

(a) Non-instrument runway

Where physically practicable, a simple approach lighting system as specified in 9.4.2 to 9.4.9 should be provided to serve a non-instrument runway where the code number is 3 or 4 and intended for use at night, except when the runway is used only in conditions of good visibility and sufficient guidance is provided by other visual aids.

Note. — A simple approach lighting system can also provide visual guidance by day.

(b) Non-precision approach runway

Where physically practicable, a simple approach lighting system as specified in 9.4.2 to 9.4.9 shall be provided to serve a non-precision approach runway, except when the runway is used only in conditions of good visibility or sufficient guidance is provided by other visual aids.

Note — It is advisable to give consideration to the installation of a precision approach category I lighting system or to the addition of a runway lead-in lighting system.
(c) Precision approach runway category I

Where physically practicable, a precision approach category I lighting system as specified in 9.4.10 to 9.4.21 shall be provided to serve a precision approach runway category I.

(d) Precision approach runway categories II and III

A precision approach category II and III lighting system as specified in 9.4.22 to 9.4.39 shall be provided to serve a precision approach runway category II or III.

Simple approach lighting system

Location

9.4.2 A simple approach lighting system shall consist of a row of lights on the extended centre line of the runway extending, whenever possible, over a distance of not less than 420 m from the threshold with a row of lights forming a crossbar 18 m or 30 m in length at a distance of 300 m from the threshold.

9.4.3 The lights forming the crossbar shall be as nearly as practicable in a horizontal straight line at right angles to, and bisected by, the line of the centre line lights. The lights of the crossbar shall be spaced so as to produce a linear effect, except that, when a crossbar of 30 m is used, gaps may be left on each side of the centre line. These gaps shall be kept to a minimum to meet local requirements and each shall not exceed 6 m.

Note 1.—Spacing s for the crossbar lights between 1 m and 4 m are in use. Gaps on each side of the centre line may improve directional guidance when approaches are made with a lateral error, and facilitate the movement of rescue and fire fighting vehicles.

Note 2.—See Attachment 1, Section 2, for guidance on installation tolerances.

9.4.4 The lights forming the centre line shall be placed at longitudinal intervals of 60 m, except that, when it is desired to improve the guidance, an interval of 30 m may be used. The innermost light shall be located either 60 m or 30 m from the threshold,
depending on the longitudinal interval selected for the centre
line lights.

9.4.5 If it is not physically possible to provide a centre line extending for
a distance of 420 m from the threshold, it should be extended to
300 m so as to include the crossbar. If this is not possible, the
centre line lights should be extended as far as practicable,
and each centre line light should then consist of a barrette at
least 3 m in length. Subject to the approach system having a
crossbar at 300 m from the threshold, an additional crossbar
maybe provided at 150 m from the threshold.

9.4.6 The system shall lie as nearly as practicable in the horizontal
plane passing through the threshold, provided that:

(a) no object other than an ILS azimuth antenna shall protrude
through the plane of the approach lights within a distance
of 60 m from the centre line of the system; and

(b) no light other than a light located within the central part of
a crossbar or a centre line barrette (not their extremities) shall be screened from an approaching aircraft.

Any ILS azimuth antenna protruding through the plane of the
lights shall be treated as an obstacle and marked and lighted
accordingly.

Characteristics

9.4.7 The lights of a simple approach lighting system shall be fixed
lights and the colour of the lights shall be such as to ensure that the
system is readily distinguishable from other aeronautical ground lights,
and from extraneous lighting if present. Each centre line light shall
consist of either:

(a) a single source; or

(b) a barrette at least 3 m in length.

Note 1 —When the barrette as in b) is composed of lights
approximating to point sources, a spacing of 1.5 m between adjacent
lights in the barrette has been found satisfactory.
Note 2.—It may be advisable to use barrettes 4 m in length if it is anticipated that the simple approach lighting system will be developed into a precision approach lighting system.

Note 3.—At locations where identification of the simple approach lighting system is difficult at night due to surrounding lights, sequence flashing lights installed in the outer portion of the system may resolve this problem.

9.4.8 Where provided for a non-instrument runway, the lights should show at all angles in azimuth necessary to a pilot on base leg and final approach. The intensity of the lights should be adequate for all conditions of visibility and ambient light for which the system has been provided.

9.4.9 Where provided for a non-precision approach runway, the lights should show at all angles in azimuth necessary to the pilot of an aircraft which on final approach does not deviate by an abnormal amount from the path defined by the non-visual aid. The lights should be designed to provide guidance during both day and night in the most adverse conditions of visibility and ambient light for which it is intended that the system should remain usable.

Precision approach category I lighting system

Location

9.4.10 A precision approach category I lighting system shall consist of a row of lights on the extended centre line of the runway extending, wherever possible, over a distance of 900 m from the runway threshold with a row of lights forming a crossbar 30 m in length at a distance of 300 m from the runway threshold.

Note — The installation of an approach lighting system of less than 900 m in length may result in operational limitations on the use of the runway. See Attachment 1, Section 2.

9.4.11 The lights forming the crossbar shall be as nearly as practicable in a horizontal straight line at right angles to, and bisected by, the line of the centre line lights. The lights of the crossbar shall be spaced so as to produce a linear effect, except that gaps may be left on each
side of the centre line. These gaps shall be kept to a minimum to meet local requirements and each shall not exceed 6 m.

Note 1.—Spacing for the crossbar lights between 1 m and 4 m are in use. Gaps on each side of the centre line may improve directional guidance when approaches are made with a lateral error, and facilitate the movement of rescue and fire fighting vehicles.

Note 2.—See Attachment 1, Section 2, for guidance on installation tolerances.

9.4.12 The lights forming the centre line shall be placed at longitudinal intervals of 30 m with the innermost light located 30 m from the threshold.

9.4.13 The system shall lie as nearly as practicable in the horizontal plane passing through the threshold, provided that:

(a) no object other than an ILS azimuth antenna shall protrude through the plane of the approach lights within a distance of 60 m from the centre line of the system; and

(b) no light other than a light located within the central part of a crossbar or a centre line barrette (not their extremities) shall be screened from an approaching aircraft.

Any ILS azimuth antenna protruding through the plane of the lights shall be treated as an obstacle and marked and lighted accordingly.

**Characteristics**

9.4.14 The centre line and crossbar lights of a precision approach category I lighting system shall be fixed lights showing variable white. Each centre line light position shall consist of either:

(a) a single light source in the innermost 300 m of the centre line, two light sources in the central 300 m of the centre line and three light sources in the outer 300 m of the centre line to provide distance information; or

(b) a barrette.
9.4.15 Where the serviceability level of the approach lights specified as a maintenance objective in Annex 14 Vol. 1, 10.5.10 can be demonstrated, each centre line light position may consist of either:

(a) a single light source; or

(b) a barrette.

9.4.16 The barrettes shall be at least 4 m in length. When barrettes are composed of lights approximating to point sources, the lights shall be uniformly spaced at intervals of not more than 1.5 m.

9.4.17 If the centre line consists of barrettes as described in 9.4.14 b) or 9.4.15 b), each barrette should be supplemented by a capacitor discharge light, except where such lighting is considered unnecessary taking into account the characteristics of the system and the nature of the meteorological conditions.

9.4.18 Each capacitor discharge light as described in 9.4.17 shall be flashed twice a second in sequence, beginning with the outermost light and progressing toward the threshold to the innermost light of the system. The design of the electrical circuit shall be such that these lights can be operated independently of the other lights of the approach lighting system.

9.4.19 If the centre line consists of lights as described in 9.4.14 a) or 9.4.15 a), additional crossbars of lights to the crossbar provided at 300 m from the threshold shall be provided at 150 m, 450 m, 600 m and 750 m from the threshold. The lights forming each crossbar shall be as nearly as practicable in a horizontal straight line at right angles to, and bisected by, the line of the centre line lights. The lights shall be spaced so as to produce a linear effect, except that gaps may be left on each side of the centre line. These gaps shall be kept to a minimum to meet local requirements and each shall not exceed 6 m.

Note.—See Attachment 1, Section 2, for detailed configuration.
9.4.20 Where the additional crossbars described in 9.4.19 are incorporated in the system, the outer ends of the crossbars shall lie on two straight lines that either are parallel to the line of the centre line lights or converge to meet the runway centre line 300 m from threshold.

9.4.21 The lights shall be in accordance with the specifications of Appendix C, Figure C1-1.

Note.—The flight path envelopes used in the design of these lights are given in Attachment 1, Figure A-4.

**Precision approach category II and III lighting system**

**Location**

9.4.22 The approach lighting system shall consist of a row of lights on the extended centre line of the runway, extending, wherever possible, over a distance of 900 m from the runway threshold. In addition, the system shall have two side rows of lights, extending 270 m from the threshold, and two crossbars, one at 150 m and one at 300 m from the threshold, all as shown in Appendix A, Figure A1-4. Where the serviceability level of the approach lights specified as maintenance objectives in ASD 501 Part 11.2.7 can be demonstrated, the system may have two side rows of lights, extending 240 m from the threshold, and two crossbars, one at 150 m and one at 300 m from the threshold, all as shown in Appendix A, Figure A1-5.

Note.—The length of 900 m is based on providing guidance for operations under category I, II and III conditions. Reduced lengths may support category II and III operations but may impose limitations on category I operations. See Attachment 1, Section 2.

9.4.23 The lights forming the centre line shall be placed at longitudinal intervals of 30 m with the innermost lights located 30 m from the threshold.

9.4.24 The lights forming the side rows shall be placed on each side of the centre line, at a longitudinal spacing equal to that of the centre line lights and with the first light located 30 m from the threshold. Where the serviceability level of the approach lights specified as maintenance objectives in ASD 501 Part 11.2.7 can
be demonstrated, lights forming the side rows may be placed on each side of the centre line, at a longitudinal spacing of 60 m with the first light located 60 m from the threshold. The lateral spacing (or gauge) between the innermost lights of the side rows shall be not less than 18 m nor more than 22.5 m, and preferably 18 m, but in any event shall be equal to that of the touchdown zone lights.

9.4.25 The crossbar provided at 150 m from the threshold shall fill in the gaps between the centre line and side row lights.

9.4.26 The crossbar provided at 300 m from the threshold shall extend on both sides of the centre line lights to a distance of 15 m from the centre line.

9.4.27 If the centre line beyond a distance of 300 m from the threshold consists of lights as described in 9.4.31 b) or 9.4.32 b), additional crossbars of lights shall be provided at 450 m, 600 m and 750 m from the threshold.

9.4.28 Where the additional crossbars described in 9.4.27 are incorporated in the system, the outer ends of these crossbars shall lie on two straight lines that either are parallel to the centre line or converge to meet the runway centre line 300 m from the threshold.

9.4.29 The system shall lie as nearly as practicable in the horizontal plane passing through the threshold, provided that:

(a) no object other than an ILS azimuth antenna shall protrude through the plane of the approach lights within a distance of 60 m from the centre line of the system; and

(b) no light other than a light located within the central part of a crossbar or a centre line barrette (not their extremities) shall be screened from an approaching aircraft.

Any ILS azimuth antenna protruding through the plane of the lights shall be treated as an obstacle and marked and lighted accordingly.
Characteristics

9.4.30 The centre line of a precision approach category II and III lighting system for the first 300 m from the threshold shall consist of barrettes showing variable white, except that, where the threshold is displaced 300 m or more, the centre line may consist of single light sources showing variable white. Where the serviceability level of the approach lights specified as maintenance objectives in ASD 501 Part 11.2.7 can be demonstrated, the centre line of a precision approach category II and III lighting system for the first 300 m from the threshold may consist of either:

(a) barrettes, where the centre line beyond 300 m from the threshold consists of barrettes as described in 9.4.32 a); or

(b) alternate single light sources and barrettes, where the centre line beyond 300 m from the threshold consists of single light sources as described in 9.4.32 b), with the innermost single light source located 30 m and the innermost barrette located 60 m from the threshold; or

(c) single light sources where the threshold is displaced 300 m or more;

all of which shall show variable white.

9.4.31 Beyond 300 m from the threshold each centre line light position shall consist of either:

(a) a barrette as used on the inner 300 m; or

(b) two light sources in the central 300 m of the centre line and three light sources in the outer 300 m of the centre line;

all of which shall show variable white.

9.4.32 Where the serviceability level of the approach lights specified as maintenance objectives in ASD 501 Part 11.2.7 can be demonstrated, beyond 300 m from the threshold each centre line light position may consist of either:

(a) a barrette; or

(b) a single light source;
all of which shall show variable white.

9.4.33 The barrettes shall be at least 4 m in length. When barrettes are composed of lights approximating to point sources, the lights shall be uniformly spaced at intervals of not more than 1.5 m.

9.4.34 If the centre line beyond 300 m from the threshold consists of barrettes as described in 9.4.31 a) or 9.4.32 a), each barrette beyond 300 m should be supplemented by a capacitor discharge light, except where such lighting is considered unnecessary taking into account the characteristics of the system and the nature of the meteorological conditions.

9.4.35 Each capacitor discharge light shall be flashed twice a second in sequence, beginning with the outermost light and progressing toward the threshold to the innermost light of the system. The design of the electrical circuit shall be such that these lights can be operated independently of the other lights of the approach lighting system.

9.4.36 The side row shall consist of barrettes showing red. The length of a side row barrette and the spacing of its lights shall be equal to those of the touchdown zone light barrettes.

9.4.37 The lights forming the crossbars shall be fixed lights showing variable white. The lights shall be uniformly spaced at intervals of not more than 2.7 m.

9.4.38 The intensity of the red lights shall be compatible with the intensity of the white lights.

9.4.39 The lights shall be in accordance with the specifications of Appendix C, Figures C1-1 and C1-2.

Note.—The flight path envelopes used in the design of these lights are given in Attachment 1, Figure A-4.
9.5 Visual approach slope indicator systems

Application

9.5.1 A visual approach slope indicator system shall be provided to serve the approach to a runway whether or not the runway is served by other visual approach aids or by non-visual aids, where one or more of the following conditions exist:

(a) the runway is used by turbojet or other aeroplanes with similar approach guidance requirements;

(b) the pilot of any type of aeroplane may have difficulty in judging the approach due to:

   (1) inadequate visual guidance such as is experienced during an approach over water or featureless terrain by day or in the absence of sufficient extraneous lights in the approach area by night; or

   (2) misleading information such as is produced by deceptive surrounding terrain or runway slopes;

(c) the presence of objects in the approach area may involve serious hazard if an aeroplane descends below the normal approach path, particularly if there are no non-visual or other visual aids to give warning of such objects;

(d) physical conditions at either end of the runway present a serious hazard in the event of an aeroplane undershooting or overrunning the runway; and

(e) terrain or prevalent meteorological conditions are such that the aeroplane may be subjected to unusual turbulence during approach.

Note.— Guidance on the priority of installation of visual approach slope indicator systems is contained in Attachment 1, Section 3.

9.5.2 The standard visual approach slope indicator systems shall consist of the following:
(a) T-VASIS and AT-VASIS conforming to the specifications contained in 9.5.6 to 9.5.22 inclusive;

(b) PAPI and APAPI systems conforming to the specifications contained in 9.5.23 to 9.5.40 inclusive; as shown in Appendix A, Figure A1-6.

9.5.3 PAPI, T-VASIS or AT-VASIS shall be provided where the code number is 3 or 4 when one or more of the conditions specified in 9.5.1 exist.

9.5.4 PAPI or APAPI shall be provided where the code number is 1 or 2 when one or more of the conditions specified in 9.5.1 exist.

9.5.5 Where a runway threshold is temporarily displaced from the normal position and one or more of the conditions specified in 9.5.1 exist, a PAPI should be provided except that where the code number is 1 or 2 an APAPI may be provided.

**T-VASIS and AT-VASIS**

**Description**

9.5.6 The T-VASIS shall consist of twenty light units symmetrically disposed about the runway centre line in the form of two wing bars of four light units each, with bisecting longitudinal lines of six lights, as shown in Appendix A, Figure A1-7.

9.5.7 The AT-VASIS shall consist of ten light units arranged on one side of the runway in the form of a single wing bar of four light units with a bisecting longitudinal line of six lights.

9.5.8 The light units shall be constructed and arranged in such a manner that the pilot of an aeroplane during an approach will:

(a) when above the approach slope, see the wing bar(s) white, and one, two or three fly-down lights, the more fly-down lights being visible the higher the pilot is above the approach slope;

(b) when on the approach slope, see the wing bar(s) white; and
(c) when below the approach slope, see the wing bar(s) and one, two or three fly-up lights white, the more fly-up lights being visible the lower the pilot is below the approach slope; and when well below the approach slope, see the wing bar(s) and the three fly-up lights red.

When on or above the approach slope, no light shall be visible from the fly-up light units; when on or below the approach slope, no light shall be visible from the fly-down light units.

Siting

9.5.9 The light units shall be located as shown in Appendix A, Figure A1-7, subject to the installation tolerances given therein.

Note.—The siting of T-VASIS will provide, for a 3° slope and a nominal eye height of 15 m (see 9.5.6 and 9.5.19), a pilot’s eye height of 13 m to 17 m when only the wing bar lights are visible. If increased eye height at the threshold is required (to provide adequate wheel clearance), then the approaches may be flown with one or more fly-down lights visible. The pilot’s eye height over the threshold is then of the following order:

(i). Wing bar lights and one fly-down light visible 17 m to 22 m
(ii). Wing bar lights and two fly-down lights visible 22 m to 28 m
(iii). Wing bar lights and three fly-down lights visible 28 m to 54 m

Characteristics of the light units

9.5.10 The systems shall be suitable for both day and night operations.

9.5.11 The light distribution of the beam of each light unit shall be of fan shape showing over a wide arc in azimuth in the approach direction. The wing bar light units shall produce a beam of white light from 1°54′ vertical angle up to 6° vertical angle and a beam of red light from 0° to 1°54′ vertical angle. The fly-down light units shall produce a white beam extending from an elevation of 6° down to approximately the approach slope, where it shall have a sharp cut-off. The fly-up light units shall produce a white beam from approximately the approach slope down to 1°54′ vertical angle and a red beam below a 1°54′
vertical angle. The angle of the top of the red beam in the wing bar units and fly-up units may be increased to comply with 9.5.21.

9.5.12 The light intensity distribution of the fly-down, wing bar and fly-up light units shall be as shown in Appendix C, Figure C1-22.

9.5.13 The colour transition from red to white in the vertical plane shall be such as to appear to an observer, at a distance of not less than 300 m, to occur over a vertical angle of not more than 15°.

9.5.14 At full intensity the red light shall have a Y coordinate not exceeding 0.320.

9.5.15 A suitable intensity control shall be provided to allow adjustments to meet the prevailing conditions and to avoid dazzling the pilot during approach and landing.

9.5.16 The light units forming the wing bars, or the light units forming a fly-down or a fly-up matched pair, shall be mounted so as to appear to the pilot of an approaching aeroplane to be substantially in a horizontal line. The light units shall be mounted as low as possible and shall be frangible.

9.5.17 The light units shall be so designed that deposits of condensation, dirt, etc., on optically transmitting or reflecting surfaces shall interfere to the least possible extent with the light signals and shall in no way affect the elevation of the beams or the contrast between the red and white signals. The construction of the light units shall be such as to minimize the probability of the slots being wholly or partially blocked by snow or ice where these conditions are likely to be encountered.

Approach slope and elevation setting of light beams

9.5.18 The approach slope shall be appropriate for use by the aeroplanes using the approach.

9.5.19 When the runway on which a T-VASIS is provided is equipped with an ILS and/or MLS, the sitting and elevations of the light units shall be such that the visual approach slope conforms as closely as possible with the glide path of the ILS and/or the minimum glide path of the MLS, as appropriate.
9.5.20 The elevation of the beams of the wing bar light units on both sides of the runway shall be the same. The elevation of the top of the beam of the fly-up light unit nearest to each wing bar, and that of the bottom of the beam of the fly-down light unit nearest to each wing bar, shall be equal and shall correspond to the approach slope. The cut-off angle of the top of the beams of successive fly-up light units shall decrease by 5′ of arc in angle of elevation at each successive unit away from the wing bar. The cut-in angle of the bottom of the beam of the fly-down light units shall increase by 7′ of arc at each successive unit away from the wing bar (see Appendix A, Figure A1-8).

9.5.21 The elevation setting of the top of the red light beams of the approach, the pilot of an aeroplane to whom the wing bar and three fly-up light units are visible would clear all objects in the approach area by a safe margin if any such light did not appear red.

9.5.22 The azimuth spread of the light beam shall be suitably restricted where an object located outside the obstacle protection surface of the system, but within the lateral limits of its light beam, is found to extend above the plane of the obstacle protection surface and an aeronautical study indicates that the object could adversely affect the safety of operations. The extent of the restriction shall be such that the object remains outside the confines of the light beam.

Note. — See ASD 501 Part 9.5.41 to 9.5.45 concerning the related obstacle protection surface.

PAPI and APAPI

Description

9.5.23 The PAPI system shall consist of a wing bar of 4 sharp transition multi-lamp (or paired single lamp) units equally spaced. The system shall be located on the left side of the runway unless it is physically impracticable to do so.

Note. — Where a runway is used by aircraft requiring visual roll guidance which is not provided by other external means, then a second wing bar may be provided on the opposite side of the runway.
9.5.24 The APAPI system shall consist of a wing bar of 2 sharp transition multi-lamp (or paired single lamp) units. The system shall be located on the left side of the runway unless it is physically impracticable to do so.

Note. — Where a runway is used by aircraft requiring visual roll guidance which is not provided by other external means, then a second wing bar may be provided on the opposite side of the runway.

9.5.25 The wing bar of a PAPI shall be constructed and arranged in such a manner that a pilot making an approach will:

(a) when on or close to the approach slope, see the two units nearest the runway as red and the two units farthest from the runway as white;

(b) when above the approach slope, see the one unit nearest the runway as red and the three units farthest from the runway as white; and when further above the approach slope, see all the units as white; and

(c) when below the approach slope, see the three units nearest the runway as red and the unit farthest from the runway as white; and when further below the approach slope, see all the units as red.

9.5.26 The wing bar of an APAPI shall be constructed and arranged in such a manner that a pilot making an approach will:

(a) when on or close to the approach slope, see the unit nearer the runway as red and the unit farther from the runway as white;

(b) when above the approach slope, see both the units as white; and

(c) when below the approach slope, see both the units as red.

Siting

9.5.27 The light units shall be located as in the basic configuration illustrated in Appendix A, Figure A1-9, subject to the installation tolerances given therein. The units forming a wing bar shall be mounted so as to appear to the pilot of an approaching
aeroplane to be substantially in a horizontal line. The light units shall be mounted as low as possible and shall be frangible.

**Characteristics of the light units**

9.5.28 The system shall be suitable for both day and night operations.

9.5.29 The colour transition from red to white in the vertical plane shall be such as to appear to an observer, at a distance of not less than 300 m, to occur within a vertical angle of not more than 3'.

9.5.30 At full intensity the red light shall have a Y coordinate not exceeding 0.320.

9.5.31 The light intensity distribution of the light units shall be as shown in Appendix C, Figure C1-23.

*Note.— See the ICAO Aerodrome Design Manual (Doc 9157), Part 4, for additional guidance on the characteristics of light units.*

9.5.32 Suitable intensity control shall be provided so as to allow adjustment to meet the prevailing conditions and to avoid dazzling the pilot during approach and landing.

9.5.33 Each light unit shall be capable of adjustment in elevation so that the lower limit of the white part of the beam may be fixed at any desired angle of elevation between 1°30' and at least 4°30' above the horizontal.

9.5.34 The light units shall be so designed that deposits of condensation, snow, ice, dirt, etc., on optically transmitting or reflecting surfaces shall interfere to the least possible extent with the light signals and shall not affect the contrast between the red and white signals and the elevation of the transition sector.

**Approach slope and elevation setting of light units**

9.5.35 The approach slope as defined in Appendix A, Figure A1-10 shall be appropriate for use by the aeroplanes using the approach.
9.5.36 When the runway is equipped with an ILS and/or MLS, the siting and the angle of elevation of the light units shall be such that the visual approach slope conforms as closely as possible with the glide path of the ILS and/or the minimum glide path of the MLS, as appropriate.

9.5.37 The angle of elevation settings of the light units in a PAPI wing bar shall be such that, during an approach, the pilot of an aeroplane observing a signal of one white and three reds will clear all objects in the approach area by a safe margin (see Table B1-1).

9.5.38 The angle of elevation settings of the light units in an APAPI wing bar shall be such that, during an approach, the pilot of an aeroplane observing the lowest on slope signal, i.e. one white and one red, will clear all objects in the approach area by a safe margin (see Appendix B, Table B1-1).

9.5.39 The azimuth spread of the light beam shall be suitably restricted where an object located outside the obstacle protection surface of the PAPI or APAPI system, but within the lateral limits of its light beam, is found to extend above the plane of the obstacle protection surface and an aeronautical study indicates that the object could adversely affect the safety of operations. The extent of the restriction shall be such that the object remains outside the confines of the light beam.

Note. — See 9.5.41 to 9.5.45 concerning the related obstacle protection surface.

9.5.40 Where wing bars are installed on each side of the runway to angle so that the signals of each wing bar change symmetrically at the same time.

Obstacle protection surface

Note. — The following specifications apply to T-VASIS, ATVASIS, PAPI and APAPI.

9.5.41 An obstacle protection surface shall be established when it is intended to provide a visual approach slope indicator system.
9.5.42 The characteristics of the obstacle protection surface, i.e. origin, divergence, length and slope, shall correspond to those specified in the relevant column of Appendix B Table B1-2 and in Appendix A, Figure A1-11.

9.5.43 New objects or extensions of existing objects shall not be permitted above an obstacle protection surface except when, in the opinion of the appropriate authority, the new object or extension would be shielded by an existing immovable object.

Note. — Circumstances in which the shielding principle may reasonably be applied are described in the ICAO Airport Services Manual (Doc 9137), Part 6.

9.5.44 Existing objects above an obstacle protection surface shall be removed except when, in the opinion of the appropriate authority, the object is shielded by an existing immovable object, or after aeronautical study it is determined that the object would not adversely affect the safety of operations of aeroplanes.

9.5.45 Where an aeronautical study indicates that an existing object extending above an obstacle protection surface could adversely affect the safety of operations of aeroplanes one or more of the following measures shall be taken:

(a) suitably raise the approach slope of the system;

(b) reduce the azimuth spread of the system so that the object is outside the confines of the beam;

(c) displace the axis of the system and its associated obstacle protection surface by no more than 5°;

(d) suitably displace the threshold; and

(e) where (d) is found to be impracticable, suitably displace the system upwind of the threshold to provide an increase in threshold crossing height equal to the height of the object penetration.

Note. — Guidance on this issue is contained in the ICAO Aerodrome Design Manual (Doc 9157), Part 4.
9.6 Circling guidance lights

Application

9.6.1 Circling guidance lights should be provided when existing approach and runway lighting systems do not satisfactorily permit identification of the runway and/or approach area to a circling aircraft in the conditions for which it is intended the runway be used for circling approaches.

Location

9.6.2 The location and number of circling guidance lights should be adequate to enable a pilot, as appropriate, to:

(a) join the downwind leg or align and adjust the aircraft’s track to the runway at a required distance from it and to distinguish the threshold in passing; and

(b) keep in sight the runway threshold and/or other features which will make it possible to judge the turn on to base leg and final approach, taking into account the guidance provided by other visual aids.

9.6.3 Circling guidance lights should consist of:

(a) lights indicating the extended centre line of the runway and/or parts of any approach lighting system; or

(b) lights indicating the position of the runway threshold; or

(c) lights indicating the direction or location of the runway;

or a combination of such lights as is appropriate to the runway under consideration.

Note.—Guidance on installation of circling guidance lights is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 4.
Characteristics

9.6.4 Circling guidance lights should be fixed or flashing lights of an intensity and beam spread adequate for the conditions of visibility and ambient light in which it is intended to make visual circling approaches. The flashing lights should be white, and the steady lights either white or gaseous discharge lights.

9.6.5 The lights should be designed and be installed in such a manner that they will not dazzle or confuse a pilot when approaching to land, taking off or taxiing.

9.7 Runway lead-in lighting systems

Application

9.7.1 A runway lead-in lighting system should be provided where it is desired to provide visual guidance along a specific approach path, for reasons such as avoiding hazardous terrain or for purposes of noise abatement.

Note.— Guidance on providing lead-in lighting systems is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 4.

Location

9.7.2 A runway lead-in lighting system should consist of groups of lights positioned so as to define the desired approach path and so that one group may be sighted from the preceding group. The interval between adjacent groups should not exceed approximately 1 600 m.

Note. — Runway lead-in lighting systems may be curved, straight or a combination thereof.

9.7.3 A runway lead-in lighting system should extend from a point as determined by the appropriate authority, up to a point where the approach lighting system, if provided, or the runway or the runway lighting system is in view.
Characteristics

9.7.4 Each group of lights of a runway lead-in lighting system should consist of at least three flashing lights in a linear or cluster configuration. The system may be augmented by steady burning lights where such lights would assist in identifying the system.

9.7.5 The flashing lights should be white, and the steady burning lights gaseous discharge lights.

9.7.6 Where practicable, the flashing lights in each group should flash in sequence towards the runway.

9.8 Runway threshold identification lights

Application

9.8.1 Runway threshold identification lights should be installed:

(a) at the threshold of a non-precision approach runway when additional threshold conspicuity is necessary or where it is not practicable to provide other approach lighting aids; and

(b) where a runway threshold is permanently displaced from the runway extremity or temporarily displaced from the normal position and additional threshold conspicuity is necessary.

Location

9.8.2 Runway threshold identification lights shall be located symmetrically about the runway centre line, in line with the threshold and approximately 10 m outside each line of runway edge lights.
Characteristics

9.8.3 Runway threshold identification lights should be flashing white lights with a flash frequency between 60 and 120 per minute.

9.8.4 The lights shall be visible only in the direction of approach to the runway.

9.9 Runway edge lights

Application

9.9.1 Runway edge lights shall be provided for a runway intended for use at night or for a precision approach runway intended for use by day or night.

9.9.2 Runway edge lights should be provided on a runway intended for take-off with an operating minimum below an RVR of the order of 800 m by day.

Location

9.9.3 Runway edge lights shall be placed along the full length of the runway and shall be in two parallel rows equidistant from the centre line.

9.9.4 Runway edge lights shall be placed along the edges of the area declared for use as the runway or outside the edges of the area at a distance of not more than 3 m.

9.9.5 Where the width of the area which could be declared as runway exceeds 60 m, the distance between the rows of lights should be determined taking into account the nature of the operations, the light distribution characteristics of the runway edge lights, and other visual aids serving the runway.
9.9.6 The lights shall be uniformly spaced in rows at intervals of not more than 60 m for an instrument runway, and at intervals of not more than 100 m for a non-instrument runway. The lights on opposite sides of the runway axis shall be on lines at right angles to that axis. At intersections of runways, lights may be spaced irregularly or omitted, provided that adequate guidance remains available to the pilot.

Characteristics

9.9.7 Runway edge lights shall be fixed lights showing variable white, except that:

(a) in the case of a displaced threshold, the lights between the beginning of the runway and the displaced threshold shall show red in the approach direction; and

(b) a section of the lights 600 m or one-third of the runway length, whichever is the less, at the remote end of the runway from the end at which the take-off run is started, may show yellow.

9.9.8 The runway edge lights shall show at all angles in azimuth necessary to provide guidance to a pilot landing or taking off in either direction. When the runway edge lights are intended to provide circling guidance, they shall show at all angles in azimuth (see 9.6.1).

9.9.9 In all angles of azimuth required in 9.9.8, runway edge lights shall show at angles up to 15° above the horizontal with an intensity adequate for the conditions of visibility and ambient light in which use of the runway for take-off or landing is intended. In any case, the intensity shall be at least 50 cd except that at an aerodrome without extraneous lighting, the intensity of the lights may be reduced to not less than 25 cd to avoid dazzling the pilot.

9.9.10 Runway edge lights on a precision approach runway shall be in accordance with the specifications of Appendix C, Figure C1-9 or C1-10.
9.10 Runway threshold and wing bar lights (see Appendix A, Figure A-18)

Application of runway threshold lights

9.10.1 Runway threshold lights shall be provided for a runway equipped with runway edge lights, except on a non-instrument or non-precision approach runway where the threshold is displaced and wing bar lights are provided.

Location of runway threshold lights

9.10.2 When a threshold is at the extremity of a runway, the threshold lights shall be placed in a row at right angles to the runway axis as near to the extremity of the runway as possible and, in any case, not more than 3 m outside the extremity.

9.10.3 When a threshold is displaced from the extremity of a runway, threshold lights shall be placed in a row at right angles to the runway axis at the displaced threshold.

9.10.4 Threshold lighting shall consist of:

(a) on a non-instrument or non-precision approach runway, at least six lights;

(b) on a precision approach runway category I, at least the number of lights that would be required if the lights were uniformly spaced at intervals of 3 m between the rows of runway edge lights; and

(c) on a precision approach runway category II or III, lights uniformly spaced between the rows of runway edge lights at intervals of not more than 3 m.

9.10.5 The lights prescribed in 9.10.4 a) and b) should be either:

(a) equally spaced between the rows of runway edge lights; or

(b) symmetrically disposed about the runway centre line in two groups, with the lights uniformly spaced in each group and
with a gap between the groups equal to the gauge of the touchdown zone marking or lighting, where such is provided, or otherwise not more than half the distance between the rows of runway edge lights.

**Application of wing bar lights**

9.10.6 Wing bar lights should be provided on a precision approach runway when additional conspicuity is considered desirable.

9.10.7 Wing bar lights shall be provided on a non-instrument or non-precision approach runway where the threshold is displaced and runway threshold lights are required, but are not provided.

**Location of wing bar lights**

9.10.8 Wing bar lights shall be symmetrically disposed about the runway centre line at the threshold in two groups, i.e. wing bars. Each wing bar shall be formed by at least five lights extending at least 10 m outward from, and at right angles to, the line of the runway edge lights, with the innermost light of each wing bar in the line of the runway edge lights.

**Characteristics of runway threshold and wing bar lights**

9.10.9 Runway threshold and wing bar lights shall be fixed unidirectional lights showing green in the direction of approach to the runway. The intensity and beam spread of the lights shall be adequate for the conditions of visibility and ambient light in which use of the runway is intended.

9.10.10 Runway threshold lights on a precision approach runway shall be in accordance with the specifications of Appendix C, Figure C1-3.

9.10.11 Threshold wing bar lights on a precision approach runway shall be in accordance with the specifications of Appendix C, Figure C1-4.
9.11 Runway end lights (see Appendix A, Figure A-18)

Application

9.11.1 Runway end lights shall be provided for a runway equipped with runway edge lights.

Note. — When the threshold is at the runway extremity, fittings serving as threshold lights may be used as runway end lights.

Location

9.11.2 Runway end lights shall be placed on a line at right angles to the runway axis as near to the end of the runway as possible and, in any case, not more than 3 m outside the end.

9.11.3 Runway end lighting should consist of at least six lights. The lights should be either:

(a) equally spaced between the rows of runway edge lights; or

(b) symmetrically disposed about the runway centre line in two groups with the lights uniformly spaced in each group and with a gap between the groups of not more than half the distance between the rows of runway edge lights.

For a precision approach runway category III, the spacing between runway end lights, except between the two innermost lights if a gap is used, should not exceed 6 m.

Characteristics

9.11.4 Runway end lights shall be fixed unidirectional lights showing red in the direction of the runway. The intensity and beam spread of the lights shall be adequate for the conditions of visibility and ambient light in which use of the runway is intended.

9.11.5 Runway end lights on a precision approach runway shall be in accordance with the specifications of Appendix C, Figure C1-8.
9.12 Runway centre line lights

Application

9.12.1 Runway centre line lights shall be provided on a precision approach runway category II or III.

9.12.2 Runway centre line lights should be provided on a precision approach runway category I, particularly when the runway is used by aircraft with high landing speeds or where the width between the runway edge lights is greater than 50 m.

9.12.3 Runway centre line lights shall be provided on a runway intended to be used for take-off with an operating minimum below an RVR of the order of 400 m.

9.12.4 Runway centre line lights should be provided on a runway intended to be used for take-off with an operating minimum of an RVR of the order of 400 m or higher when used by aeroplanes with a very high take-off speed, particularly where the width between the runway edge lights is greater than 50 m.

Location

9.12.5 Runway centre line lights shall be located along the centre line of the runway, except that the lights may be uniformly offset to the same side of the runway centre line by not more than 60 cm where it is not practicable to locate them along the centre line. The lights shall be located from the threshold to the end at longitudinal spacing of approximately 15 m. Where the serviceability level of the runway centre line lights specified as maintenance objectives in ASD 501 Part 11.2.7 or ASD 501 Part 11.2.11, as appropriate, can be demonstrated and the runway is intended for use in runway visual range conditions of 350 m or greater, the longitudinal spacing may be approximately 30 m.

Note. — Existing centre line lighting where lights are spaced at 7.5 m need not be replaced.

9.12.6 Centre line guidance for take-off from the beginning of a runway to a displaced threshold should be provided by:
(a) an approach lighting system if its characteristics and intensity settings afford the guidance required during take-off and it does not dazzle the pilot of an aircraft taking off; or

(b) runway centre line lights; or

(c) barrettes of at least 3 m in length and spaced at uniform intervals of 30 m, as shown in Appendix A, Figure A1-13, designed so that their photometric characteristics and intensity setting afford the guidance required during take-off without dazzling the pilot of an aircraft taking off.

Where necessary, provision should be made to extinguish those centre line lights specified in b) or reset the intensity of the approach lighting system or barrettes when the runway is being used for landing. In no case should only the single source runway centre line lights show from the beginning of the runway to a displaced threshold when the runway is being used for landing.

Characteristics

9.12.7 Runway centre line lights shall be fixed lights showing variable white from the threshold to the point 900 m from the runway end; alternate red and variable white from 900 m to 300 m from the runway end; and red from 300 m to the runway end, except that for runways less than 1 800 m in length, the alternate red and variable white lights shall extend from the midpoint of the runway usable for landing to 300 m from the runway end.

Note.—Care is required in the design of the electrical system to ensure that failure of part of the electrical system will not result in a false indication of the runway distance remaining.

9.12.8 Runway centre line lights shall be in accordance with the specifications of Appendix C, Figure C1-6 or C1-7.
9.13 Runway touchdown zone lights

Application

9.13.1 Touchdown zone lights shall be provided in the touchdown zone of a precision approach runway category II or III.

Location

9.13.2 Touchdown zone lights shall extend from the threshold for a longitudinal distance of 900 m, except that, on runways less than 1 800 m in length, the system shall be shortened so that it does not extend beyond the midpoint of the runway. The pattern shall be formed by pairs of barrettes symmetrically located about the runway centre line. The lateral spacing between the innermost lights of a pair of barrettes shall be equal to the lateral spacing selected for the touchdown zone marking. The longitudinal spacing between pairs of barrettes shall be either 30 m or 60 m.

Note.— To allow for operations at lower visibility minima, it may be advisable to use a 30 m longitudinal spacing between barrettes.

Characteristics

9.13.3 A barrette shall be composed of at least three lights with a pacing between the lights of not more than 1.5 m.

9.13.4 A barrette should be not less than 3 m nor more than 4.5 m in length.

9.13.5 Touchdown zone lights shall be fixed unidirectional lights showing variable white.

9.13.6 Touchdown zone lights shall be in accordance with the specifications of Appendix C, Figure C1-5.
9.14 Simple touchdown zone lights

Note. — The purpose of simple touchdown zone lights is to provide pilots with enhanced situational awareness in all visibility conditions and to help enable pilots to decide whether to commence a go-around if the aircraft has not landed by a certain point on the runway. It is essential that pilots operating at aerodromes with simple touchdown zone lights be familiar with the purpose of these lights.

Application

19.4.1 Except where TDZ lights are provided in accordance with paragraph 9.13, at an aerodrome where the approach angle is greater than 3.5 degrees and/or the Landing Distance Available combined with other factors increases the risk of an overrun, simple touchdown zone lights should be provided.

Location

19.14.2 Simple touchdown zone lights shall be a pair of lights located on each side of the runway centreline 0.3 m beyond the upwind edge of the final touchdown zone marking. The lateral spacing between the inner lights of the two pairs of lights shall be equal to the lateral spacing selected for the touchdown zone marking. The spacing between the lights of the same pair shall not be more than 1.5 m or half the width of the touchdown zone marking, whichever is greater. (Appendix A, Figure A1-19)

19.14.3 Where provided on a runway without TDZ markings, simple touchdown zone lights should be installed in such a position that provides the equivalent TDZ information.
Characteristics

19.14.4 Simple touchdown zone lights shall be fixed unidirectional lights showing variable white, aligned so as to be visible to the pilot of a landing aeroplane in the direction of approach to the runway.

19.14.5 Simple touchdown zone lights shall be in accordance with the specifications in Appendix C, Figure C1-5.

Note. — As a good operating practice, simple touchdown zone lights are supplied with power on a separate circuit to other runway lighting so that they may be used when other lighting is switched off.

9.15 Rapid exit taxiway indicator lights

Note.— The purpose of rapid exit taxiway indicator lights (RETILs) is to provide pilots with distance-to-go information to the nearest rapid exit taxiway on the runway, to enhance situational awareness in low visibility conditions and enable pilots to apply braking action for more efficient roll-out and runway exit speeds. It is essential that pilots operating at aerodromes with runway(s) displaying rapid exit taxiway indicator lights be familiar with the purpose of these lights.

Application

9.15.1 Rapid exit taxiway indicator lights should be provided on a runway intended for use in runway visual range conditions less than a value of 350 m and/or where the traffic density is heavy.

Note.—See Attachment 1, Section 4.

9.15.2 Rapid exit taxiway indicator lights shall not be displayed in the event of any lamp failure or other failure that prevents the display of the light pattern depicted in Figure Appendix A, Figure A1-14, in full.
Location

9.15.3 A set of rapid exit taxiway indicator lights shall be located on the runway on the same side of the runway centre line as the associated rapid exit taxiway, in the configuration shown in Appendix A, Figure A1-14. In each set, the lights shall be located 2 m apart and the light nearest to the runway centre line shall be displaced 2 m from the runway centre line.

9.15.4 Where more than one rapid exit taxiway exists on a runway, the set of rapid exit taxiway indicator lights for each exit shall not overlap when displayed.

Characteristics

9.15.5 Rapid exit taxiway indicator lights shall be fixed unidirectional yellow lights, aligned so as to be visible to the pilot of a landing aeroplane in the direction of approach to the runway.

9.15.6 Rapid exit taxiway indicator lights shall be in accordance with the specifications in Appendix C, Figure C1-6 or Figure C1-7, as appropriate.

9.15.7 Rapid exit taxiway indicator lights should be supplied with power on a separate circuit to other runway lighting so that they may be used when other lighting is switched off.

9.16 Stopway lights

Application

9.16.1 Stopway lights shall be provided for a stopway intended for use at night.
Location

9.16.2 Stopway lights shall be placed along the full length of the stopway and shall be in two parallel rows that are equidistant from the centre line and coincident with the rows of the runway edge lights. Stopway lights shall also be provided across the end of a stopway on a line at right angles to the stopway axis as near to the end of the stopway as possible and, in any case, not more than 3 m outside the end.

Characteristics

9.16.3 Stopway lights shall be fixed unidirectional lights showing red in the direction of the runway.

9.17 Taxiway centre line lights

Application

9.17.1 Taxiway centre line lights shall be provided on an exit taxiway and taxiway facility and apron intended for use in runway visual range conditions less than a value of 350 m in such a manner as to provide continuous guidance between the runway centre line and aircraft stands, except that these lights need not be provided where the traffic density is light and taxiway edge lights and centre line marking provide adequate guidance.

9.17.2 Taxiway centre line lights should be provided on a taxiway intended for use at night in runway visual range conditions of 350 m or greater, and particularly on complex taxiway intersections and exit taxiways, except that these lights need not be provided where the traffic density is light and taxiway edge lights and centre line marking provide adequate guidance.

Note.— Where there may be a need to delineate the edges of a taxiway, e.g. on a rapid exit taxiway, narrow taxiway or in snow conditions, this may be done with taxiway edge lights or markers.
9.17.3 Taxiway centre line lights should be provided on an exit taxiway, taxiway and apron in all visibility conditions where specified as components of an advanced surface movement guidance and control system in such a manner as to provide continuous guidance between the runway centre line and aircraft stands.

9.17.4 Taxiway centre line lights shall be provided on a runway forming part of a standard taxi-route and intended for taxiing in runway visual range conditions less than a value of 350 m, except that these lights need not be provided where the traffic density is light and taxiway edge lights and centre line marking provide adequate guidance.

Note.— See ASD 501 Part 10.2.3 for provisions concerning the interlocking of runway and taxiway lighting systems.

9.17.5 Taxiway centre line lights should be provided in all visibility conditions on a runway forming part of a standard taxi-route where specified as components of an advanced surface movement guidance and control system.

Characteristics

9.17.6 Except as provided for in 19.17.8, Taxiway centre line lights on a taxiway other than an exit taxiway and on a runway forming part of a standard taxi-route shall be fixed lights showing green with beam dimensions such that the light is visible only from aeroplanes on or in the vicinity of the taxiway.

9.17.7 Taxiway centre line lights on an exit taxiway shall be fixed lights. Alternate taxiway centre line lights shall show green and yellow from their beginning near the runway centre line to the perimeter of the ILS critical/sensitive area or the lower edge of the inner transitional surface, whichever is farthest from the runway; and thereafter all lights shall show green (Appendix A, Figure A1-15). The first light in the exit centre line shall always show green, and the light nearest to the perimeter shall always show yellow.

Note 1. — Care is necessary to limit the light distribution of green lights on or near a runway so as to avoid possible confusion with threshold lights.

Note 2. — For yellow filter characteristics see Attachment 2, Section 1.2.
Note 3. — The size of the ILS critical/sensitive area depends on the characteristics of the associated ILS and other factors. Guidance is provided in ICAO Annex 10, Volume I, Attachments C and G.

Note 4. — See ASD 502 Part 10.3 for specifications on runway vacated signs.

9.17.8 Where it is necessary to denote the proximity to a runway, taxiway centre line lights should be fixed lights showing alternating green and yellow from the perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface, whichever is farthest from the runway, to the runway and continue alternating green and yellow until:

a) their end point near the runway centre line; or

b) in the case of the taxiway centre line lights crossing the runway, to the opposite perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface, whichever is farthest from the runway.

Note 1.— Care is necessary to limit the light distribution of green lights on or near a runway so as to avoid possible confusion with threshold lights.

Note 2.— The provisions of 19.17.8 can form part of effective runway incursion prevention measures.

9.17.9 Taxiway centre line lights shall be in accordance with the specifications of:

(a) Appendix C, Figure C1-12, C1-13, or C1-14, for taxiways intended for use in runway visual range conditions of less than a value of 350 m; and

(b) Appendix C, Figure C1-15 or C1-16, for other taxiways.

9.17.10 Where higher intensities are required, from an operational point of view, taxiway centre line lights on rapid exit taxiways intended for use in runway visual range conditions less than a value of 350 m should be in accordance with the specifications of Appendix C, Figure C1-12. The number of levels of brilliancy settings for these lights should be the same as that for the runway centre line lights.
9.17.11 Where taxiway centre line lights are specified as components of
an advanced surface movement guidance and control
system and where, from an operational point of view, higher
intensities are required to maintain ground movements at a
certain speed in very low visibilities or in bright daytime
conditions, taxiway centre line lights should be in accordance
with the specifications of Appendix C, Figure C1-17, C1-18 or C1-
19.

Note.— High-intensity centre line lights should only be used in case of
an absolute necessity and following a specific study.

Location

9.17.12 Taxiway centre line lights should normally be located on the
taxiway centre line marking, except that they may be offset by
not more than 30 cm where it is not practicable to locate them
on the marking.

Taxiway centre line lights on taxiways

Location

9.17.13 Taxiway centre line lights on a straight section of a taxiway
should be spaced at longitudinal intervals of not more than 30 m,
except that:

(a) larger intervals not exceeding 60 m may be used where,
because of the prevailing meteorological conditions, adequate
guidance is provided by such spacing;

(b) intervals less than 30 m should be provided on short straight
sections; and

(c) on a taxiway intended for use in RVR conditions of less than
a value of 350 m, the longitudinal spacing should not exceed 15
m.

9.17.14 Taxiway centre line lights on a taxiway curve should continue
from the straight portion of the taxiway at a constant distance
from the outside edge of the taxiway curve. The lights should be
9.17.15 On a taxiway intended for use in RVR conditions of less than a value of 350 m, the lights on a curve should not exceed a spacing of 15 m, and on a curve of less than 400 m radius the lights should be spaced at intervals of not greater than 7.5 m. This spacing should extend for 60 m before and after the curve.

Note 1. — Spacing on curves that have been found suitable for a taxiway intended for use in RVR conditions of 350 m or greater are:

<table>
<thead>
<tr>
<th>Curve radius</th>
<th>Light spacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 400 m</td>
<td>7.5 m</td>
</tr>
<tr>
<td>401 m to 899 m</td>
<td>15 m</td>
</tr>
<tr>
<td>900 m or greater</td>
<td>30 m</td>
</tr>
</tbody>
</table>

Note 2. — See ICAO Annex 14 Vol. 1,3.9.6 and Figure 3-2.

Taxiway centre line lights on rapid exit taxiways

Location

9.17.16 Taxiway centre line lights on a rapid exit taxiway should commence at a point at least 60 m before the beginning of the taxiway centre line curve and continue beyond the end of the curve to a point on the centre line of the taxiway where an aeroplane can be expected to reach normal taxiing speed. The lights on that portion parallel to the runway centre line should always be at least 60 cm from any row of runway centre line lights, as shown in Figure A1-16.

9.17.17 The lights should be spaced at longitudinal intervals of not more than 15 m, except that, where runway centre line lights are not provided, a greater interval not exceeding 30 m may be used.
Taxiway centre line lights on other exit taxiways

Location

9.17.18 Taxiway centre line lights on exit taxiways other than rapid exit taxiways should commence at the point where the taxiway centre line marking begins to curve from the runway centre line, and follow the curved taxiway centre line marking at least to the point where the marking leaves the runway. The first light should be at least 60 cm from any row of runway centre line lights, as shown in Figure A1-16.

9.17.19 The lights should be spaced at longitudinal intervals of not more than 7.5 m.

Taxiway centre line lights on runways

Location

9.17.20 Taxiway centre line lights on a runway forming part of a standard taxi-route and intended for taxiing in runway visual range conditions less than a value of 350 m should be spaced at longitudinal intervals not exceeding 15 m.

9.18 Taxiway edge lights

Application

9.18.1 Taxiway edge lights shall be provided at the edges of a runway, apron, holding bay, etc., intended for use at night and on a taxiway not provided with taxiway centre line lights and intended for use at night, except that taxiway edge lights need not be provided where, considering the nature of the operations, adequate guidance can be achieved by surface illumination or other means.

Note. — See ICAO Annex 14 Vol. 1, 5.5.5 for taxiway edge markers.
9.18.2 Taxiway edge lights shall be provided on a runway forming part of a standard taxi-route and intended for taxiing at night where the runway is not provided with taxiway centre line lights.

Note. — See ASD 501 Part 10.2.3 for provisions concerning the interlocking of runway and taxiway lighting systems.

Location

9.18.3 Taxiway edge lights on a straight section of a taxiway and on a runway forming part of a standard taxi-route should be spaced at uniform longitudinal intervals of not more than 60 m. The lights on a curve should be spaced at intervals less than 60 m so that a clear indication of the curve is provided.

Note.— Guidance on the spacing of taxiway edge lights on curves is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 4.

9.18.4 Taxiway edge lights on a holding bay, apron, etc., should be spaced at uniform longitudinal intervals of not more than 60 m.

9.18.5 Taxiway edge lights on a runway turn pad should be spaced at uniform longitudinal intervals of not more than 30 m.

9.18.6 The lights should be located as near as practicable to the edges of the taxiway, runway turn pad, holding bay, apron or runway, etc., or outside the edges at a distance of not more than 3 m.

Characteristics

9.18.7 Taxiway edge lights shall be fixed lights showing blue. The lights shall show up to at least 75° above the horizontal and at all angles in azimuth necessary to provide guidance to a pilot taxiing in either direction. At an intersection, exit or curve the lights shall be shielded as far as practicable so that they cannot be seen in angles of azimuth in which they may be confused with other lights.

9.18.8 The intensity of taxiway edge lights shall be at least 2 cd from 0° to 6° vertical, and 0.2 cd at any vertical angles between 6° and 75°.
9.19 Runway turn pad lights

Application

9.19.1 Runway turn pad lights shall be provided for continuous guidance on a runway turn pad intended for use in runway visual range conditions less than a value of 350 m, to enable an aeroplane to complete a 180-degree turn and align with the runway centre line.

9.19.2 Runway turn pad lights should be provided on a runway turn pad intended for use at night.

Location

9.19.3 Runway turn pad lights should normally be located on the runway turn pad marking, except that they may be offset by not more than 30 cm where it is not practicable to locate them on the marking.

9.19.4 Runway turn pad lights on a straight section of the runway turn pad marking should be spaced at longitudinal intervals of not more than 15 m.

9.19.5 Runway turn pad lights on a curved section of the runway turn pad marking should not exceed a spacing of 7.5 m.

Characteristics

9.19.6 Runway turn pad lights shall be unidirectional fixed lights showing green with beam dimensions such that the light is visible only from aeroplanes on or approaching the runway turn pad.

9.19.7 Runway turn pad lights shall be in accordance with the specifications of Appendix C, Figure C1-13, C1-14 or C1-15, as appropriate.
9.20 Stop bars

Application

Note 1. — The provision of stop bars requires their control either manually or automatically by air traffic services.

Note 2. — Runway incursions may take place in all visibility or weather conditions. The provision of stop bars at runway-holding positions and their use at night and in visibility conditions greater than 550 m runway visual range can form part of effective runway incursion prevention measures.

9.20.1 A stop bar shall be provided at every runway-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions less than a value of 350 m, except where:

(a) appropriate aids and procedures are available to assist in preventing inadvertent incursions of aircraft and vehicles onto the runway; or

(b) operational procedures exist to limit, in runway visual range conditions less than a value of 550 m, the number of:

(1) aircraft on the manoeuvring area to one at a time; and

(2) vehicles on the manoeuvring area to the essential minimum.

9.20.2 A stop bar shall be provided at every runway-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions of values between 350 m and 550 m, except where:

(a) appropriate aids and procedures are available to assist in preventing inadvertent incursions of aircraft and vehicles onto the runway; or

(b) operational procedures exist to limit, in runway visual range conditions less than a value of 550 m, the number of:

(1) aircraft on the manoeuvring area to one at a time; and

(2) vehicles on the manoeuvring area to the essential minimum.
9.20.3 Where there is more than one stop bar associated with a taxiway/runway intersection, only one shall be illuminated at any given time.

9.20.4 A stop bar should be provided at an intermediate holding position when it is desired to supplement markings with lights and to provide traffic control by visual means.

Location

9.20.5 Stop bars shall be located across the taxiway at the point where it is desired that traffic stop. Where the additional lights specified in 9.20.7 are provided, these lights shall be located not less than 3 m from the taxiway edge.

Characteristics

9.20.6 Stop bars shall consist of lights spaced at intervals of 3 m across the taxiway, showing red in the intended direction(s) of approach to the intersection or runway-holding position.

Note.— Where necessary to enhance conspicuity of an existing stop bar, extra lights are installed uniformly.

9.20.7 A pair of elevated lights should be added to each end of the stop bar where the in-pavement stop bar lights might be obscured from a pilot’s view, for example, by snow or rain, or where a pilot may be required to stop the aircraft in a position so close to the lights that they are blocked from view by the structure of the aircraft.

9.20.8 Stop bars installed at a runway-holding position shall be unidirectional and shall show red in the direction of approach to the runway.

9.20.9 Where the additional lights specified in 19.20.7 are provided, these lights shall have the same characteristics as the lights in the stop bar, but shall be visible to approaching aircraft up to the stop bar position.
9.20.10 The intensity in red light and beam spreads of stop bar lights shall be in accordance with the specifications in Appendix C, Figures C1-12 through C1-16, as appropriate.

9.20.11 Where stop bars are specified as components of an advanced surface movement guidance and control system and where, from an operational point of view, higher intensities are required to maintain ground movements at a certain speed in very low visibilities or in bright daytime conditions, the intensity in red light and beam spreads of stop bar lights should be in accordance with the specifications of Appendix C, Figures C1-17, C1-18 or C1-19.

Note.— High-intensity stop bars should only be used in case of an absolute necessity and following a specific study.

9.20.12 Where a wide beam fixture is required, the intensity in red light and beam spreads of stop bar lights should be in accordance with the specifications of Appendix C, Figure C1-17 or C1-19.

9.20.13 The lighting circuit shall be designed so that:

(a) stop bars located across entrance taxiways are selectively switchable;

(b) stop bars located across taxiways intended to be used only as exit taxiways are switchable selectively or in groups;

(c) when a stop bar is illuminated, any taxiway centre line lights installed beyond the stop bar shall be extinguished for a distance of at least 90 m; and

(d) stop bars shall be interlocked with the taxiway centre line lights so that when the centre line lights beyond the stop bar are illuminated the stop bar is extinguished and vice versa.

Note. — Care is required in the design of the electrical system to ensure that all of the lights of a stop bar will not fail at the same time. Guidance on this issue is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 5.
9.21 Intermediate holding position lights

Note. — See ICAO Annex 14 Vol.1, 5.2.11 for specifications on intermediate holding position marking.

Application

9.21.1 Except where a stop bar has been installed, intermediate holding position lights shall be provided at an intermediate holding position intended for use in runway visual range conditions less than a value of 350 m.

9.21.2 Intermediate holding position lights should be provided at an intermediate holding position where there is no need for stop-and-go signals as provided by a stop bar.

Location

9.21.3 Intermediate holding position lights shall be located along the intermediate holding position marking at a distance of 0.3 m prior to the marking.

Characteristics

9.21.4 Intermediate holding position lights shall consist of three fixed unidirectional lights showing yellow in the direction of approach to the intermediate holding position with a light distribution similar to taxiway centre line lights if provided. The lights shall be disposed symmetrically about and at right angle to the taxiway centre line, with individual lights spaced 1.5 m apart.

9.22 Runway guard lights

Note. — The purpose of runway guard lights is to warn pilots, and drivers of vehicles when they are operating on taxiways, that they are about to enter an active runway. There are two standard configurations of runway guard lights as illustrated in Appendix A, Figure A1-18.
Application

9.22.1 Runway guard lights, Configuration A, shall be provided at each taxiway/runway intersection associated with a runway intended for use in:

(a) runway visual range conditions less than a value of 550 m where a stop bar is not installed; and

(b) runway visual range conditions of values between 550 m and 1 200 m where the traffic density is heavy.

9.22.2 As part of runway incursion prevention measures, runway guard lights, Configuration A or B, should be provided at each taxiway/runway intersection where runway incursion hot spots have been identified, and used under all weather conditions during day and night.

9.22.3 Configuration B runway guard lights should not be collocated with a stop bar.

Location

9.22.4 Runway guard lights, Configuration A, shall be located at each side of the taxiway at a distance from the runway centre line not less than that specified for a take-off runway in Annex 14 Vol.1, Table 3-2.

9.22.5 Runway guard lights, Configuration B, shall be located across the taxiway at a distance from the runway centre line not less than that specified for a take-off runway in Annex 14 Vol.1, Table 3-2.

Characteristics

9.22.6 Runway guard lights, Configuration A, shall consist of two pairs of yellow lights.

9.22.7 Where there is a need to enhance the contrast between the on and off state of runway guard lights, Configuration A, intended for use during the day, a visor of sufficient size to prevent sunlight
from entering the lens without interfering with the function of the fixture should be located above each lamp.

Note.— Some other device or design, e.g. specially designed optics, may be used in lieu of the visor.

9.22.8 Runway guard lights, Configuration B, shall consist of yellow lights spaced at intervals of 3 m across the taxiway.

9.22.9 The light beam shall be unidirectional and aligned so as to be visible to the pilot of an aeroplane taxiing to the holding position.

9.22.10 The intensity in yellow light and beam spreads of lights of Configuration A should be in accordance with the specifications in Appendix C, Figure C1-24.

9.22.11 Where runway guard lights are intended for use during the day, the intensity in yellow light and beam spreads of lights of configuration A should be in accordance with the specifications in Appendix C, Figure C1-25.

9.22.12 Where runway guard lights are specified as components of an advanced surface movement guidance and control system where higher light intensities are required, the intensity in yellow light and beam spreads of lights of Configuration A should be in accordance with the specifications in Appendix C, Figure C1-25.

Note.— Higher light intensities may be required to maintain ground movement at a certain speed in low visibilities.

9.22.13 The intensity in yellow light and beam spreads of lights of Configuration B should be in accordance with the specifications in Appendix C, Figure C1-12.

9.22.14 Where runway guard lights are intended for use during the day, the intensity in yellow light and beam spreads of lights of Configuration B should be in accordance with the specifications in Appendix C, Figure C1-20.

9.22.15 Where runway guard lights are specified as components of an advanced surface movement guidance and control system where higher light intensities are required, the intensity in yellow light and beam spreads of lights of Configuration B should be in accordance with the specifications in Appendix C, Figure C1-20.
9.22.16 The lights in each unit of Configuration A shall be illuminated alternately.

9.22.17 For Configuration B, adjacent lights shall be alternately illuminated and alternative lights shall be illuminated in unison.

9.22.18 The lights shall be illuminated between 30 and 60 cycles per minute and the light suppression and illumination periods shall be equal and opposite in each light.

Note. — The optimum flash rate is dependent on the rise and fall times of the lamps used. Runway guard lights, Configuration A, installed on 6.6 ampere series circuits have been found to look best when operated at 45 to 50 flashes per minute per lamp. Runway guard lights, Configuration B, installed on 6.6 ampere series circuits have been found to look best when operated at 30 to 32 flashes per minute per lamp.

9.23 Apron floodlighting (see also 9.17.1 and 9.18.1)

Application

9.23.1 Apron floodlighting should be provided on an apron, on a de-icing/anti-icing facility, and on a designated isolated aircraft parking position intended to be used at night.


Note 2. — Guidance on apron floodlighting is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 4.

Location

9.23.2 Apron floodlights should be located so as to provide adequate illumination on all apron service areas, with a minimum of glare to pilots of aircraft in flight and on the ground, aerodrome and apron controllers, and personnel on the apron. The arrangement and aiming of floodlights should be such that an aircraft stand receives light from two or more directions to minimize shadows.
Characteristics

9.23.3 The spectral distribution of apron floodlights shall be such that the colours used for aircraft marking connected with routine servicing, and for surface and obstacle marking, can be correctly identified.

9.23.4 The average illuminance should be at least the following:

(a) Aircraft stand:
   - horizontal illuminance — 20 lux with a uniformity ratio (average to minimum) of not more than 4 to 1; and
   - vertical illuminance — 20 lux at a height of 2 m above the apron in relevant directions.

(b) Other apron areas:
   - horizontal illuminance — 50 per cent of the average illuminance on the aircraft stands with a uniformity ratio (average to minimum) of not more than 4 to 1.

9.24 Aircraft stand manoeuvring guidance lights

Application

9.24.1 Aircraft stand manoeuvring guidance lights should be provided to facilitate the positioning of an aircraft on an aircraft stand on a paved apron or on a de-icing/anti-icing facility intended for use in poor visibility conditions, unless adequate guidance is provided by other means.

Location

9.24.2 Aircraft stand manoeuvring guidance lights shall be collocated with the aircraft stand markings.
Characteristics

9.24.3 Aircraft stand manoeuvring guidance lights, other than those indicating a stop position, shall be fixed yellow lights, visible throughout the segments within which they are intended to provide guidance.

9.24.4 The lights used to delineate lead-in, turning and lead-out lines should be spaced at intervals of not more than 7.5 m on curves and 15 m on straight sections.

9.24.5 The lights indicating a stop position shall be fixed unidirectional lights showing red.

9.24.6 The intensity of the lights should be adequate for the condition of visibility and ambient light in which the use of the aircraft stand is intended.

9.24.7 The lighting circuit should be designed so that the lights may be switched on to indicate that an aircraft stand is to be used and switched off to indicate that it is not to be used.

9.25 Road-holding position light

Application

9.25.1 A road-holding position light shall be provided at each road-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions less than a value of 350 m.

9.25.2 A road-holding position light should be provided at each road-holding position serving a runway when it is intended that the runway will be used in runway visual range conditions of values between 350 m and 550 m.

Location
9.25.3 A road-holding position light shall be located adjacent to the holding position marking 1.5 m (±0.5 m) from one edge of the road, i.e. left or right as appropriate to the local traffic regulations.

Note.— See ICAO Annex 14 Vol. 1, 9.9 for the mass and height limitations and frangibility requirements of navigation aids located on runway strips.

Characteristics

9.25.4 The road-holding position light shall comprise:

(a) a controllable red (stop)/green (go) traffic light; or

(b) a flashing-red light.

Note.— It is intended that the lights specified in sub-paragraph a) be controlled by the air traffic services.

9.25.5 The road-holding position light beam shall be unidirectional and aligned so as to be visible to the driver of a vehicle approaching the holding position.

9.25.6 The intensity of the light beam shall be adequate for the conditions of visibility and ambient light in which the use of the holding position is intended, but shall not dazzle the driver.

Note.— The commonly used traffic lights are likely to meet the requirements in 9.25.5 and 9.25.6.

9.25.7 The flash frequency of the flashing-red light shall be between 30 and 60 flashes per minute.

9.26 No-entry bar

Note 1.— A no-entry bar is intended to be controlled manually by air traffic services.

Note 2.— Runway incursions may take place in all visibility or weather conditions. The provision of no-entry bars at taxiway/runway
intersections and their use at night and in all visibility conditions can form part of effective runway incursion.

Application

9.26.1 A no-entry bar should be provided across a taxiway which is intended to be used as an exit only taxiway to assist in preventing inadvertent access of traffic to that taxiway.

Location

9.26.2 A no-entry bar should be located across the taxiway at the end of an exit only taxiway where it is desired to prevent traffic from entering the taxiway in the wrong direction.

Characteristics

9.26.3 A no-entry bar should consist of unidirectional lights spaced at uniform intervals of no more than 3 m showing red in the intended direction(s) of approach to the runway.

Note.— Where necessary to enhance conspicuity, extra lights are installed uniformly.

9.26.4 A pair of elevated lights should be added to each end of the no-entry bar where the in pavement no entry bar lights might be obscured from a pilot’s view, for example, by snow or rain, or where a pilot may be required to stop the aircraft in a position so close to the lights that they are blocked from view by the structure of the aircraft.

9.26.5 The intensity in red light and beam spreads of no-entry bar lights shall be in accordance with the specifications in Appendix C, Figures C1-12 through C1-16, as appropriate.

9.26.6 Where no-entry bars are specified as components of an advanced surface movement guidance and control system and where, from an operational point of view, higher intensities are required to maintain ground movements at a certain speed in very low visibilities or in bright daytime conditions, the intensity in
red light and beam spreads of no-entry bar lights should be in accordance with the specifications of Appendix C, Figure C1-17, C1-18 or C1-19.

Note.— High-intensity no-entry bars are typically used only in case of an absolute necessity and following a specific study.

9.26.7 Where a wide beam fixture is required, the intensity in red light and beam spreads of No-entry bar lights should be in accordance with the specifications of Appendix C, Figure C1-17 or C1-19.

9.26.8 The lighting circuit shall be designed so that:

a) no-entry bars are switchable selectively or in groups;

b) when a no-entry bar is illuminated, any taxiway centre line lights installed beyond the no-entry bar, when viewed towards the runway, shall be extinguished for a distance of at least 90 m; and

c) When a no-entry bar is illuminated, any stop bar installed between the no-entry bar and the runway shall be extinguished.

9.27 Visual docking guidance system

Application

9.27.1 A visual docking guidance system shall be provided when it is intended to indicate, by a visual aid, the precise positioning of an aircraft on an aircraft stand and other alternative means, such as marshallers, are not practicable.

Note.— The factors to be considered in evaluating the need for a visual docking guidance system are in particular: the number and type(s) of aircraft using the aircraft stand, weather conditions, space available on the apron and the precision required for manoeuvring into the parking position due to aircraft servicing installation, passenger loading bridges, etc. See the Aerodrome Design Manual (Doc 9157), Part 4 — Visual Aids for guidance on the selection of suitable systems.
Characteristics

9.27.2 The system shall provide both azimuth and stopping guidance.

9.27.3 The azimuth guidance unit and the stopping position indicator shall be adequate for use in all weather, visibility, background lighting and pavement conditions for which the system is intended, both by day and night, but shall not dazzle the pilot.

Note.— Care is required in both the design and on-site installation of the system to ensure that reflection of sunlight, or other light in the vicinity, does not degrade the clarity and conspicuity of the visual cues provided by the system.

9.27.4 The azimuth guidance unit and the stopping position indicator shall be of a design such that:

a) a clear indication of malfunction of either or both is available to the pilot; and

b) they can be turned off.

9.27.5 The azimuth guidance unit and the stopping position indicator shall be located in such a way that there is continuity of guidance between the aircraft stand markings, the aircraft stand manoeuvring guidance lights, if present, and the visual docking guidance system.

9.27.6 The accuracy of the system shall be adequate for the type of loading bridge and fixed aircraft servicing installations with which it is to be used.

9.27.7 The system should be usable by all types of aircraft for which the aircraft stand is intended, preferably without selective operation.

9.27.8 If selective operation is required to prepare the system for use by a particular type of aircraft, then the system shall provide an identification of the selected aircraft type to both the pilot and the system operator as a means of ensuring that the system has been set properly.
**Azimuth Guidance Unit**

**Location**

9.27.9 The azimuth guidance unit shall be located on or close to the extension of the stand centre line ahead of the aircraft so that its signals are visible from the cockpit of an aircraft throughout the docking manoeuvre and aligned for use at east by the pilot occupying the left seat.

9.27.10 The azimuth guidance unit should be aligned for use by the pilots occupying both the left and right seats.

**Characteristics**

9.27.11 The azimuth guidance unit shall provide unambiguous left/right guidance which enables the pilot to acquire and maintain the lead-in line without over-controlling.

9.27.12 When azimuth guidance is indicated by colour change, green shall be used to identify the centre line and red for deviations from the centre line.

**Stopping Position Indicator**

**Location**

9.27.13 The stopping position indicator shall be located in conjunction with, or sufficiently close to, the azimuth guidance unit so that a pilot can observe both the azimuth and stop signals without turning the head.

9.27.14 The stopping position indicator shall be usable at least by the pilot occupying the left seat.

9.27.15 The stopping position indicator should be usable by the pilots occupying both the left and right seats.
Characteristics

9.27.16 The stopping position information provided by the indicator for a particular aircraft type shall account for the anticipated range of variations in pilot eye height and/or viewing angle.

9.27.17 The stopping position indicator shall show the stopping position for the aircraft for which guidance is being provided and shall provide closing rate information to enable the pilot to gradually decelerate the aircraft to a full stop at the intended stopping position.

9.27.18 The stopping position indicator should provide closing rate information over a distance of at least 10 m.

9.27.19 When stopping guidance is indicated by colour change, green shall be used to show that the aircraft can proceed and red to show that the stop point has been reached, except that for a short distance prior to the stop point a third colour may be used to warn that the stopping point is close.

9.28 Advanced Visual Docking Guidance System

Application

Note 1.— Advanced visual docking guidance systems (A-VDGS) include those systems that, in addition to basic and passive azimuth and stop position information, provide pilots with active (usually sensor-based) guidance information, such as aircraft type indication (in accordance with Doc 8643 — Aircraft Type Designators), distance-to-go information and closing speed. Docking guidance information is usually provided on a single display unit.

Note 2.— An A-VDGS may provide docking guidance information in three stages: the acquisition of the aircraft by the system, the azimuth alignment of the aircraft, and the stopping position information.

9.28.1 An A-VDGS should be provided where it is operationally desirable to confirm the correct aircraft type for which guidance is being provided and/or to indicate the stand centre line in use, where more than one is provided for.

9.28.2 The A-VDGS shall be suitable for use by all types of aircraft for which the aircraft stand is intended.
9.28.3 The A-VDGS shall be used only in conditions in which its operational performance is specified.

Note 1.— The use of the A-VDGS in conditions such as weather, visibility and background lighting, both by day and night, would need to be specified.

Note 2.— Care is required in both the design and on-site installation of the system to ensure that glare, reflection of sunlight, or other light in the vicinity, does not degrade the clarity and conspicuity of the visual cues provided by the system.

9.28.4 The docking guidance information provided by an A-VDGS shall not conflict with that provided by a conventional visual docking guidance system on an aircraft stand if both types are provided and are in operational use. A method of indicating that the A-VDGS is not in operational use or is unserviceable shall be provided.

Location

9.28.5 The A-VDGS shall be located such that unobstructed and unambiguous guidance is provided to the person responsible for, and persons assisting, the docking of the aircraft throughout the docking manoeuvre.

Note.— Usually the pilot-in-command is responsible for the docking of the aircraft. However, in some circumstances, another person could be responsible and this person may be the driver of a vehicle that is towing the aircraft.

Characteristics

9.28.6 The A-VDGS shall provide, at minimum, the following guidance information at the appropriate stage of the docking manoeuvre:

a) an emergency stop indication;

b) the aircraft type and model for which the guidance is provided;
c) an indication of the lateral displacement of the aircraft relative to the stand centre line;

d) the direction of azimuth correction needed to correct a displacement from the stand centre line;

e) an indication of the distance to the stop position;

f) an indication when the aircraft has reached the correct stopping position; and

g) a warning indication if the aircraft goes beyond the appropriate stop position.

9.28.7 The A-VDGS shall be capable of providing docking guidance information for all aircraft taxi speeds encountered during the docking manoeuvre.

Note.— See the Aerodrome Design Manual (Doc 9157), Part 4, for an indication of the maximum aircraft speeds relative to distance to the stopping position.

9.28.8 The time taken from the determination of the lateral displacement to its display shall not result in a deviation of the aircraft, when operated in normal conditions, from the stand centre line greater than 1 m.

9.28.9 The information on displacement of the aircraft relative to the stand centre line and distance to the stopping position, when displayed, should be provided with the accuracy specified in Appendix B, Table B1-3

9.28.10 Symbols and graphics used to depict guidance information shall be intuitively representative of the type of information provided.

Note.— The use of colour would need to be appropriate and need to follow signal convention, i.e. red, yellow and green mean hazard, caution and normal/correct conditions, respectively. The effects of colour contrasts would also need to be considered.

9.28.11 Information on the lateral displacement of the aircraft relative to the stand centre line shall be provided at least 25 m prior to the stop position.
Note.— The indication of the distance of the aircraft from the stop position may be colour-coded and presented at a rate and distance proportional to the actual closure rate and distance of the aircraft approaching the stop point.

9.28.12 Continuous closure distance and closure rate shall be provided from at least 15 m prior to the stop position.

9.28.13 Where provided, closure distance displayed in numerals should be provided in metre integers to the stop position and displayed to 1 decimal place at least 3 m prior to the stop position.

9.28.14 Throughout the docking manoeuvre, an appropriate means shall be provided on the A-VDGS to indicate the need to bring the aircraft to an immediate halt. In such an event, which includes a failure of the A-VDGS, no other information shall be displayed.

9.28.15 Provision to initiate an immediate halt to the docking procedure shall be made available to personnel responsible for the operational safety of the stand.

9.28.16 The word “stop” in red characters should be displayed when an immediate cessation of the docking manoeuvre is required.
10.1 Electrical power supply systems for air navigation facilities.

Introductory Note. — The safety of operations at aerodromes depends on the quality of the supplied power. The total electrical power supply system may include connections to one or more external sources of electric power supply, one or more local generating facilities and to a distribution network including transformers and switchgear. Many other aerodrome facilities supplied from the same system need to be taken into account while planning the electrical power system at aerodromes.

10.1.1 Adequate primary power supply shall be available at aerodromes for the safe functioning of air navigation facilities.

10.1.2 The design and provision of electrical power systems for aerodrome visual and radio navigation aids shall be such that an equipment failure will not leave the pilot with inadequate visual and non-visual guidance or misleading information.

Note. — The design and installation of the electrical systems need to take into consideration factors that can lead to malfunction, such as electromagnetic disturbances, line losses, power quality, etc. Additional guidance is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 5.

10.1.3 As additional requirement, all electrical system shall comply with the latest local standard/rules. The system shall be maintained by a suitable competent person who shall be registered with Suruhanjaya Tenaga or other relevant authority.

10.1.4 Electric power supply connections to those facilities for which secondary power is required should be so arranged that the facilities are automatically connected to the secondary power supply on failure of the primary source of power.

10.1.5 The time interval between failure of the primary source of power and the complete restoration of the services required by 10.2.11
should be as short as practicable, except that for visual aids associated with non-precision, precision approach or take-off runways the requirements of Appendix D, Table D1-1 for maximum switch-over times should apply.

Note.— A definition of switch-over time is given in ICAO Annex 14 Volume 1, Chapter 1.

10.1.6 The provision of a definition of switch-over time shall not require the replacement of an existing secondary power supply before 1 January 2010. However, for a secondary power supply installed after 4 November 1999, the electric power supply connections to those facilities for which secondary power is required shall be so arranged that the facilities are capable of meeting the requirements of Appendix A, Table A1-1 for maximum switch-over times as defined in ICAO Annex 14 Volume 1, Chapter 1.

Visual aids

Application

10.1.7 For a precision approach runway, a secondary power supply capable of meeting the requirements of Appendix D, Table A1-1 for the appropriate category of precision approach runway shall be provided. Electric power supply connections to those facilities for which secondary power is required shall be so arranged that the facilities are automatically connected to the secondary power supply on failure of the primary source of power.

10.1.8 For a runway meant for take-off in runway visual range conditions less than a value of 800 m, a secondary power supply capable of meeting the relevant requirements of Appendix D, Table A1-1 shall be provided.

10.1.9 At an aerodrome where the primary runway is a non-precision approach runway, a secondary power supply capable of meeting the requirements of Appendix D, Table A1-1 should be provided except that a secondary power supply for visual aids need not be provided for more than one non-precision approach runway.
10.1.10 At an aerodrome where the primary runway is a non-instrument runway, a secondary power supply capable of meeting the requirements of 10.2.4 should be provided, except that a secondary power supply for visual aids need not be provided when an emergency lighting system in accordance with the specification of ASD 501 Part 9.2 is provided and capable of being deployed in 15 minutes.

10.1.11 The following aerodrome facilities should be provided with a secondary power supply capable of supplying power when there is a failure of the primary power supply:

   a) The signalling lamp and the minimum lighting necessary to enable air traffic services personnel to carry out their duties;

      Note.—The requirement for minimum lighting may be met by other than electrical means.

   b) All obstacle lights which, in the opinion of the appropriate authority, are essential to ensure the safe operation of aircraft;

   c) Approach, runway and taxiway lighting as specified in 10.1.6 to 10.1.9;

   d) Meteorological equipment;

   e) Essential security lighting, if provided in accordance with ICAO Annex 14 Vol. 1, Part 9.11;

   f) Essential equipment and facilities for the aerodrome responding emergency agencies;

   g) Floodlighting on a designated isolated aircraft parking position if provided in accordance with ASD 501 Part 9.23.1, and

   h) Illumination of apron areas over which passengers may walk.

   Note.—Specifications for secondary power supply for radio navigation aids and ground elements of communications systems are given in ICAO Annex 10, Volume I, Chapter 2.
10.1.12 Requirements for a secondary power supply should be met by either of the following:

a) Independent public power, which is a source of power supplying the aerodrome service from a substation other than the normal substation through a transmission line following a route different from the normal power supply route and such that the possibility of a simultaneous failure of the normal and independent public power supplies is extremely remote; or

b) Standby power unit(s), which are engine generators, batteries, etc., from which electric power can be obtained.

Note.— Guidance on electrical systems is included in the ICAO Aerodrome Design Manual (Doc 9157), Part 5.

10.2 System design

10.2.1 For a runway meant for use in runway visual range conditions less than a value of 550 m, the electrical systems for the power supply, lighting and control of the lighting systems included in Appendix D, Table A1-1 shall be so designed that an equipment failure will not leave the pilot with inadequate visual guidance or misleading information.

Note.— Guidance on means of providing this protection is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 5.

10.2.2 Where the secondary power supply of an aerodrome is provided by the use of duplicate feeders, such supplies shall be physically and electrically separate so as to ensure the required level of availability and independence.

10.2.3 Where a runway forming part of a standard taxi-route is provided with runway lighting and taxiway lighting, the lighting systems shall be interlocked to preclude the possibility of simultaneous operation of both forms of lighting.
10.3 Monitoring

Note.— Guidance on this subject is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 5.

10.3.1 A system of monitoring should be employed to indicate the operational status of the lighting systems.

10.3.2 Where lighting systems are used for aircraft control purposes, such systems shall be monitored automatically so as to provide an indication of any fault which may affect the control functions. This information shall be automatically relayed to the air traffic services unit.

10.3.3 Where a change in the operational status of lights has occurred, an indication should be provided within two seconds for a stop bar at a runway-holding position and within five seconds for all other types of visual aids.

10.3.4 For a runway meant for use in runway visual range conditions less than a value of 550 m, the lighting systems detailed in Appendix A, Table A1-1 should be monitored automatically so as to provide an indication when the serviceability level of any element falls below the minimum serviceability level specified in ASD 501 Part 11.2.7 to 11.2.11, as appropriate. This information should be automatically relayed to the maintenance crew.

10.3.5 For a runway meant for use in runway visual range conditions less than a value of 550 m, the lighting systems detailed in Appendix D, Table A1-1 should be monitored automatically to provide an indication when the serviceability level of any element falls below the minimum level specified by the appropriate authority below which operations should not continue. This information should be automatically relayed to the air traffic services unit and displayed in a prominent position.

Note.— Guidance on air traffic control interface and visual aids monitoring is included in the ICAO Aerodrome Design Manual (Doc 9157), Part 5.
AERODROME MAINTENANCE FOR VISUAL AIDS

11.1 General

11.1.1 A maintenance programme, including preventive maintenance where appropriate, shall be established at an aerodrome to maintain facilities in a condition which does not impair the safety, regularity or efficiency of air navigation.

Note 1. — Preventive maintenance is programmed maintenance work done in order to prevent a failure or degradation of facilities.

Note 2. — “Facilities” are intended to include such items as pavements, visual aids, fencing, drainage systems, electrical systems and buildings.

11.1.2 The design and application of the maintenance programme should observe Human Factors principles.

Note. — Guidance material on Human Factors principles can be found in the Human Factors Training Manual (Doc 9683) and in the Airport Services Manual (Doc 9137), Part 8.

11.2 Visual aids

Note 1. — These specifications are intended to define the maintenance performance level objectives. They are not intended to define whether the lighting system is operationally out of service.

Note 2. — The energy savings of light emitting diodes (LEDs) are due in large part to the fact that they do not produce the infra-red heat signature of incandescent lamps. Aerodrome operators who have come to expect the melting of ice and snow by this heat signature may wish to evaluate whether or not a modified maintenance schedule is required during such conditions, or evaluate the possible operational value of installing LED fixtures with heating elements.

Note 3. — Enhanced vision systems (EVS) technology relies on the infra-red heat signature provided by incandescent lighting. Annex 15 protocols provide an appropriate means of notifying aerodrome users of EVS when lighting systems are converted to LED.
11.2.1 A light shall be deemed to be unserviceable when the main beam average intensity is less than 50 per cent of the value specified in the appropriate figure in Appendix 2. For light units where the designed main beam average intensity is above the value shown in Appendix 2, the 50 per cent value shall be related to that design value.

11.2.2 A system of preventive maintenance of visual aids shall be employed to ensure lighting and marking system reliability.

Note.— Guidance on preventive maintenance of visual aids is given in the Airport Services Manual (Doc 9137), Part 9.

11.2.3 The system of preventive maintenance employed for a precision approach runway category II or III should include at least the following checks:

   a) visual inspection and in-field measurement of the intensity, beam spread and orientation of lights included in the approach and runway lighting systems;

   b) control and measurement of the electrical characteristics of each circuitry included in the approach and runway lighting systems; and

   c) control of the correct functioning of light intensity settings used by air traffic control.

11.2.4 In-field measurement of intensity, beam spread and orientation of lights included in approach and runway lighting systems for a precision approach runway category II or III should be undertaken by measuring all lights, as far as practicable, to ensure conformance with the applicable specification of Appendix 2.

11.2.5 Measurement of intensity, beam spread and orientation of lights included in approach and runway lighting systems for a precision approach runway category II or III should be undertaken using a mobile measuring unit of sufficient accuracy to analyse the characteristics of the individual lights.

11.2.6 The frequency of measurement of lights for a precision approach runway category II or III should be based on traffic density, the local pollution level, the reliability of the installed lighting equipment and the continuous assessment of the results of the in-field measurements but, in any event, should not be less than twice a year for in-pavement lights and not less than once a year for other lights.
11.2.7 The system of preventive maintenance employed for a precision approach runway category II or III shall have as its objective that, during any period of category II or III operations, all approach and runway lights are serviceable and that, in any event, at least:

a) 95 per cent of the lights are serviceable in each of the following particular significant elements:
   1) precision approach category II and III lighting system, the inner 450 m;
   2) runway centre line lights;
   3) runway threshold lights; and
   4) runway edge lights;

b) 90 per cent of the lights are serviceable in the touchdown zone lights;

c) 85 per cent of the lights are serviceable in the approach lighting system beyond 450 m; and

d) 75 per cent of the lights are serviceable in the runway end lights.

In order to provide continuity of guidance, the allowable percentage of unserviceable lights shall not be permitted in such a way as to alter the basic pattern of the lighting system. Additionally, an unserviceable light shall not be permitted adjacent to another unserviceable light, except in a barrette or a crossbar where two adjacent unserviceable lights may be permitted.

Note. — With respect to barrettes, crossbars and runway edge lights, lights are considered to be adjacent if located consecutively and:

— laterally: in the same barrette or crossbar; or

— longitudinally: in the same row of edge lights or barrettes.

11.2.8 The system of preventive maintenance employed for a stop bar provided at a runway-holding position used in conjunction with a runway intended for operations in runway visual range conditions less than a value of 350 m shall have the following objectives:

a) no more than two lights will remain unserviceable; and

b) two adjacent lights will not remain unserviceable unless the light spacing is significantly less than that specified.
11.2.9 The system of preventive maintenance employed for a taxiway intended for use in runway visual range conditions less than a value of 350 m shall have as its objective that no two adjacent taxiway centre line lights be unserviceable.

11.2.10 The system of preventive maintenance employed for a precision approach runway category I shall have as its objective that, during any period of category I operations, all approach and runway lights are serviceable and that, in any event, at least 85 per cent of the lights are serviceable in each of the following:

a) precision approach category I lighting system;

b) runway threshold lights;

c) runway edge lights; and

d) runway end lights.

In order to provide continuity of guidance an unserviceable light shall not be permitted adjacent to another unserviceable light unless the light spacing is significantly less than that specified.

Note. — In barrettes and crossbars, guidance is not lost by having two adjacent unserviceable lights.

11.2.11 The system of preventive maintenance employed for a runway meant for take-off in runway visual range conditions less than a value of 550 m shall have as its objective that, during any period of operations, all runway lights are serviceable and that in any event:

a) at least 95 per cent of the lights are serviceable in the runway centre line lights (where provided) and in the runway edge lights; and

b) at least 75 per cent of the lights are serviceable in the runway end lights. In order to provide continuity of guidance, an unserviceable light shall not be permitted adjacent to another unserviceable light.
11.2.12 The system of preventive maintenance employed for a runway meant for take-off in runway visual range conditions of a value of 550 m or greater shall have as its objective that, during any period of operations, all runway lights are serviceable and that, in any event, at least 85 per cent of the lights are serviceable in the runway edge lights and runway end lights. In order to provide continuity of guidance, an unserviceable light shall not be permitted adjacent to another unserviceable light.

11.2.13 During low visibility procedures the appropriate authority should restrict construction or maintenance activities in the proximity of aerodrome electrical systems.

12. The Appendices to this Directive shall be taken, construed, read and be part of this Directive.

DATO’ SRI AZHARUDDIN ABDUL RAHMAN  
Director General  
Department of Civil Aviation  
Malaysia  

Dated : 20 APRIL 2016
APPENDIX A – VISUAL AIDS FOR NAVIGATION

Figure A1-1. Protected flight zones

Figure A1-2. Multiple runway laser-beam free flight zone
Figure A1-3. Protected flight zones with indication of maximum irradiance levels for visible laser beams.
Figure A1-4. Inner 300 m approach and runway lighting for precision approach runways, categories II and III
Figure A1-5. Inner 300 m approach and runway lighting for precision approach runways, categories II and III, where the serviceability levels of the lights specified as maintenance objectives in ICAO Annex 14 Vol. 1, Chapter 10 can be demonstrated.
Figure A1-6. Visual approach slope indicator systems
APPENDIX A – VISUAL AIDS FOR NAVIGATION

INSTALLATION TOLERANCES

The appropriate authority may:

a) vary the nominal eye height over the threshold of the on-slope signal between the limits of 12 m and 16 m, except in cases where a standard ILS glide path and/or MLS minimum glide path is available; the height over threshold should be varied to avoid any conflict between the visual approach slope indications and the usable portion of the ILS glide path and/or MLS minimum glide path indications;

b) vary the longitudinal distance between individual light units or the overall length of the system by not more than 10 per cent;

c) vary the lateral displacement of the system from the runway edge by not more than ±3 m;

Note.—The system must be symmetrically displaced about the runway centre line.

d) where there is a longitudinal slope of the ground, adjust the longitudinal distance of a light unit to compensate for its difference in level from that of the threshold; and

e) where there is a transverse slope in the ground, adjust the longitudinal distance of two light units or two wing bars to compensate for the difference in level between them as necessary to meet the requirements of 9.5.16.

The distance between the wing bar and the threshold is based on an approach slope of 3° to a level runway with a nominal eye height over the threshold of 15 m. In practice, the threshold to wing bar distance is determined by:

a) the selected approach slope;

b) the longitudinal slope of the runway; and

c) the selected nominal eye height over the threshold.

Figure A1-7. Siting of light units for T-VASIS
Figure A1-8. Light beams and elevation settings of T-VASIS and AT-VASIS
a) Where a PAPI or APAPI is installed on a runway not equipped with an ILS or MLS, the distance $D_1$ shall be calculated to ensure that the lowest height at which a pilot will see a correct approach path indication (Appendix A, Figure A1-10, angle B for a PAPI and angle A for an APAPI) provides the wheel clearance over the threshold specified in Appendix B, Table B1-1 for the most demanding amongst aeroplanes regularly using the runway.

b) Where a PAPI or APAPI is installed on a runway equipped with an ILS and/or MLS, the distance $D_1$ shall be calculated to provide the optimum compatibility between the visual and non-visual aids for the range of eye-to-antenna heights of the aeroplanes regularly using the runway. The distance shall be equal to that between the threshold and the effective origin of the ILS glide path or MLS minimum glide path, as appropriate, plus a correction factor for the variation of eye-to-antenna heights of the aeroplanes concerned. The correction factor is obtained by multiplying the average eye-to-antenna height of those aeroplanes by the cotangent of the approach angle. However, the distance shall be such that in no case will the wheel clearance over the threshold be lower than that specified in column (3) of Appendix B, Table B1-1.

Note δ: See Section ICAO Annex 14 Vol 1, 5.2.5 for specifications on aiming point marking. Guidance on the harmonization of PAPI, ILS and/or MLS signals is contained in the ICAO Aerodrome Design Manual (Doc 9157), Part 4.

c) If a wheel clearance, greater than that specified in a) above is required for specific aircraft, this can be achieved by increasing $D_1$.

d) Distance $D_1$ shall be adjusted to compensate for differences in elevation between the lens centres of the light units and the threshold.

e) To ensure that units are mounted as low as possible and to allow for any transverse slope, small height adjustments of up to 5 cm between units are acceptable. A lateral gradient not greater than 1.25 per cent can be accepted provided it is uniformly applied across the units.

f) A spacing of 6 m (±1 m) between PAPI units should be used on code numbers 1 and 2. In such an event, the inner PAPI unit shall be located not less than 10 m (±1 m) from the runway edge. Note δ: Reducing the spacing between light units results in a reduction in usable range of the system.

g) The lateral spacing between APAPI units may be increased to 9 m (±1 m) if greater range is required or later conversion to a full PAPI is anticipated. In the latter case, the inner APAPI unit shall be located 15 m (±1 m) from the runway edge.
The height of the pilot’s eye above the aircraft’s ILS glide path/MLS antenna varies with the type of aeroplane and approach attitude. Harmonization of the PAPI signal and ILS glide path and/or MLS minimum glide path to a point closer to the threshold may be achieved by increasing the on-course sector from 2° to 3°. The setting angles for a 3° glide slope would then be 2°30′, 2°45′, 3°15′, and 3°30′.

A — 3° PAPI ILLUSTRATED

B — 3° APAPI ILLUSTRATED

Figure A1-10. Light beams and angle of elevation setting of PAPI and APAPI
Figure A1-11. Obstacle protection surface for visual approach slope indicator systems
Figure A1-13. Example of approach and runway lighting for runway with displaced thresholds
Figure A1-14. Rapid exit taxiway indicator lights (RETILS)
Figure A1-15. Taxiway lighting
APPENDIX A – VISUAL AIDS FOR NAVIGATION

Figure A1-16. Offset runway and taxiway centre line lights

Figure A1-17. Runway guard lights
Figure A1-18. Arrangement of runway threshold and runway end light
Figure A1-19. Simple Touchdown zone lighting

Figure A1-20. Typical remote de-icing/anti-icing facility
### Table B1-1. Wheel clearance over threshold for PAPI and APAPI

<table>
<thead>
<tr>
<th>Eye-to-wheel height of aeroplane in the approach configuration</th>
<th>Desired wheel clearance (metres)$^{bc}$</th>
<th>Minimum wheel clearance (metres)$^{d}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to but not including 3 m</td>
<td>6</td>
<td>3$^{c}$</td>
</tr>
<tr>
<td>3 m up to but not including 5 m</td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>5 m up to but not including 8 m</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>8 m up to but not including 14 m</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

a. In selecting the eye-to-wheel height group, only aeroplanes meant to use the system on a regular basis shall be considered. The most demanding amongst such aeroplanes shall determine the eye-to-wheel height group.
b. Where practicable the desired wheel clearances shown in column (2) shall be provided.
c. The wheel clearances in column (2) may be reduced to no less than those in column (3) where an aeronautical study indicates that such reduced wheel clearances are acceptable.
d. When a reduced wheel clearance is provided at a displaced threshold it shall be ensured that the corresponding desired wheel clearance specified in column (2) will be available when an aeroplane at the top end of the eye-to-wheel height group chosen overflies the extremity of the runway.
e. This wheel clearance may be reduced to 1.5 m on runways used mainly by light-weight non-turbojet aeroplanes.

### Table B1-2. Dimensions and slopes of the obstacle protection surface

<table>
<thead>
<tr>
<th>Runway type/code number</th>
<th>Non-instrument Code number</th>
<th>Instrument Code number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Length of inner edge</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Distance from threshold</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>Divergence (each side)</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>Total length</td>
<td>7 500</td>
<td>m</td>
</tr>
</tbody>
</table>

**Slope**

a. T-VASIS and AT-VASIS
   - $-^{c}$
   - 1.9°
   - 1.9°
   - 1.9°

b. PAPI$^{d}$
   - A–0.57°
   - A–0.57°
   - A–0.57°
   - A–0.57°
   - A–0.57°
   - A–0.57°
   - A–0.57°
   - A–0.57°
   - A–0.57°


c. APAPI$^{d}$
   - A–0.9°
   - A–0.9°
   - A–0.9°
   - A–0.9°

---

a. This length is to be increased to 150 m for a T-VASIS or AT-VASIS.
b. This length is to be increased to 15 000 m for a T-VASIS or AT-VASIS.
c. No slope has been specified if a system is unlikely to be used on runway type/code number indicated.
d. Angles as indicated in Figure 5-20.
## APPENDIX B – VISUAL AIDS FOR NAVIGATION

<table>
<thead>
<tr>
<th>Guidance information</th>
<th>Maximum deviation at 9 m from stop position</th>
<th>Maximum deviation at 15 m from stop position</th>
<th>Maximum deviation at 25 m from stop position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azimuth</td>
<td>±250 mm</td>
<td>±340 mm</td>
<td>±500 mm</td>
</tr>
<tr>
<td>Distance</td>
<td>±500 mm</td>
<td>±1 000 mm</td>
<td>±1 300 mm</td>
</tr>
</tbody>
</table>

**Table B1-3  A-VDGS recommended displacement accuracy**
APPENDIX C – AERONUTICAL GROUND LIGHT CHARACTERISTICS

Figure C1-1. Isocandela diagram for approach centre line light and crossbars (white light)

Notes:

1. Curves calculated on formula \( \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \)

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>10</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>b</td>
<td>5.5</td>
<td>6.5</td>
<td>6.5</td>
<td>6.5</td>
</tr>
</tbody>
</table>

2. Vertical setting angles of the lights shall be such that the following vertical coverage of the main beam will be met:

- distance from threshold | vertical main beam coverage
  - threshold to 315 m | 0° — 11°
  - 316 m to 475 m | 0.5° — 11.5°
  - 476 m to 640 m | 1.5° — 12.5°
  - 641 m and beyond | 2.5° — 13.5° (as illustrated above)

3. Lights in crossbars beyond 22.5 m from the centre line shall be toed-in 2 degrees. All other lights shall be aligned parallel to the centre line of the runway.

4. See collective notes for Figures C1-1 to C1-11.
Figure C1-2. Isocandela diagram for approach side row light (red light)
Figure C1-3. Isocandela diagram for threshold light (green light)
Figure C1-4. Isocandela diagram for threshold wing bar light (green light)
APPENDIX C – AERONUTICAL GROUND LIGHT CHARACTERISTICS

3. See collective notes for Figures C1-1 to C1-11.

Figure C1-5. Isocandela diagram for touchdown zone light (white light)

Notes:

1. Curves calculated on formula \[ \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \]

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>a</td>
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</tr>
<tr>
<td>b</td>
<td>3.5</td>
<td>6.0</td>
</tr>
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</table>

2. Toe-in 4 degrees

3. See collective notes for Figures C1-1 to C1-11.
4. See collective notes for Figures C1-1 to C1-11.

Figure C1-6. Isocandela diagram for runway centre line light with 30 m longitudinal spacing (white light) and rapid exit taxiway indicator light (yellow light)
Figure C1-7.  Isocandela diagram for runway centre line light with 15 m longitudinal spacing (white light) and rapid exit taxiway indicator light (yellow light)

Notes:
1. Curves calculated on formula \( \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \) for red light, multiply values by 0.15.
2. For yellow light, multiply values by 0.40.
3. See collective notes for Figures C1-1 to C1-11.
APPENDIX C – AERONUTICAL GROUND LIGHT CHARACTERISTICS

Figure C1-8.  Isocandela diagram for runway end light (red light)

Notes:

1. Curves calculated on formula \( \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \)

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<td>a</td>
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<td>6.5</td>
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</table>

2. See collective notes for Figures C1-1 to C1-11.
Notes:

1. Curves calculated on formula \( \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \)

2. Toe-in 3.5 degrees

3. For red light, multiply values by 0.15.

4. For yellow light, multiply values by 0.40.

5. See collective notes for Figures C1-1 to C1-11.

<table>
<thead>
<tr>
<th></th>
<th>a</th>
<th>b</th>
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</thead>
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<td>7.5</td>
</tr>
<tr>
<td></td>
<td>3.5</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Figure C1-9. Isocandela diagram for runway edge light where width of runway is 45 m (white light)
APPENDIX C – AERONUTICAL GROUND LIGHT CHARACTERISTICS

Notes:

1. Curves calculated on formula $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$

<table>
<thead>
<tr>
<th></th>
<th>a</th>
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<th>8.5</th>
<th>10.0</th>
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<td></td>
<td></td>
<td>3.5</td>
<td>6.0</td>
<td>8.5</td>
</tr>
</tbody>
</table>

2. Toe-in 4.5 degrees

3. For red light, multiply values by 0.15.

4. For yellow light, multiply values by 0.40.

5. See collective notes for Figures C1-1 to C1-11.

Figure C1-10. Isocandela diagram for runway edge light where width of runway is 60 m (white light)
Figure C1-11. Grid points to be used for the calculation of average intensity of approach and runway lights
APPENDIX C – AERONUTICAL GROUND LIGHT CHARACTERISTICS

Collective notes to Figures C1-1 to C1-11

1. The ellipses in each figure are symmetrical about the common vertical and horizontal axes.

2. Figures C1-1 to C1-10 show the minimum allowable light intensities. The average intensity of the main beam is calculated by establishing grid points as shown in Figure C1-11 and using the intensity value measures at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic average of light intensities measured at all considered grid points.

3. No deviations are acceptable in the main beam pattern when the lighting fixture is properly aimed.

4. Average intensity ratio. The ratio between the average intensity within the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be as follows:

   | Figure C1-1 | Approach centre line and crossbars | 1.5 to 2.0 (white light) |
   | Figure C1-2 | Approach side row                  | 0.5 to 1.0 (red light)   |
   | Figure C1-3 | Threshold                           | 1.0 to 1.5 (green light) |
   | Figure C1-4 | Threshold wing bar                 | 1.0 to 1.5 (green light) |
   | Figure C1-5 | Touchdown zone                     | 0.5 to 1.0 (white light) |
   | Figure C1-6 | Runway centre line (longitudinal spacing 30 m) | 0.5 to 1.0 (white light) |
   | Figure C1-7 | Runway centre line (longitudinal spacing 15 m) | 0.5 to 1.0 for CAT III (white light) | 0.25 to 0.5 for CAT I, II (white light) |
   | Figure C1-8 | Runway end                         | 0.25 to 0.5 (red light)  |
   | Figure C1-9 | Runway edge (45 m runway width)    | 1.0 (white light)        |
   | Figure C1-10| Runway edge (60 m runway width)    | 1.0 (white light)        |

5. The beam coverages in the figures provide the necessary guidance for approaches down to an RVR of the order of 150 m and take-offs down to an RVR of the order of 100 m.

6. Horizontal angles are measured with respect to the vertical plane through the runway centre line. For lights other than centre line lights, the direction towards the runway centre line is considered positive. Vertical angles are measured with respect to the horizontal plane.

7. Where, for approach centre line lights and crossbars and for approach side row lights, inset lights are used in lieu of elevated lights, e.g. on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.
8. The importance of adequate maintenance cannot be overemphasized. The average intensity should never fall to a value less than 50 per cent of the value shown in the figures, and it should be the aim of airport authorities to maintain a level of light output close to the specified minimum average intensity.

9. The light unit shall be installed so that the main beam is aligned within one-half degree of the specified requirement.
Figure C1.12. Isocandela diagram for taxiway centre line (15 m spacing) and stop bar lights in straight sections intended for use in runway visual range conditions of less than a value of 350 m where large offsets can occur and for low-intensity runway guard lights, Configuration B

Notes:

1. These beam coverages allow for displacement of the cockpit from the centre line up to distances of the order of 12 m and are intended for use before and after curves.

2. See collective notes for Figures C1-12 to C1-21.

3. Increased intensities for enhanced rapid exit taxiway centre line lights as recommended in 9.17.9 are four times the respective intensities in the figure (i.e. 800 cd for minimum)
Notes:

1. These beam coverage are generally satisfactory and cater for a normal displacement of the cockpit from the centre line of approximately 3 m.

2. See collective notes for Figures C1-12 to C1-21.

Figure C1-13. Isocandela diagram for taxiway centre line (15 m spacing) and stop bar lights in straight sections intended for use in runway visual range conditions of less than a value of 350 m
Figure C1-14. Isocandela diagram for taxiway centre line (7.5 m spacing) and stop bar lights in curved sections intended for use in runway visual range conditions of less than a value of 350 m

Notes:

1. Lights on curves to be toed-in 15.75 degrees with respect to the tangent of the curve.

2. See collective notes for Figures C1-12 to C1-21.
Figure C1-15. Isocandela diagram for taxiway centre line (30 m, 60 m spacing) and stop bar lights in straight sections intended for use in runway visual range conditions of 350 m or greater

Notes:

1. At locations where high background luminance is usual and where deterioration of light output resulting from dust, snow and local contamination is a significant factor, the cd-values should be multiplied by 2.5.

2. Where omnidirectional lights are used they shall comply with the vertical beam requirements in this figure.

3. See collective notes for Figures C1-12 to C1-21.
Figure C1-16. Isocandela diagram for taxiway centre line (7.5 m, 15 m, 30 m spacing) and stop bar lights in curved sections intended for use in runway visual range conditions of 350 m or greater

Notes:

1. Lights on curves to be toed-in 15.75 degrees with respect to the tangent of the curve.

2. At locations where high background luminance is usual and where deterioration of light output resulting from dust, snow and local contamination is a significant factor, the cd-values should be multiplied by 2.5.

3. These beam coverages allow for displacement of the cockpit from the centre line up to distances of the order of 12 m as could occur at the end of curves.

4. See collective notes for Figures C1-12 to C1-21.
Figure C1-17. Isocandela diagram for high-intensity taxiway centre line (15 m spacing) and stop bar lights in straight sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required and where large offsets can occur.

<table>
<thead>
<tr>
<th>Curve</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>d</th>
<th>e</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intensity (cd)</td>
<td>8</td>
<td>20</td>
<td>100</td>
<td>450</td>
<td>1 800</td>
</tr>
</tbody>
</table>

Notes:

1. These beam coverages allow for displacement of the cockpit from the centre line up to distances of the order of 12 m and are intended for use before and after curves.

2. See collective notes for Figures C1-12 to C1-21.
Figure C1-18. Isocandela diagram for high-intensity taxiway centre line (15 m spacing) and stop bar lights in straight sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required.

Notes:

1. These beam coverages are generally satisfactory and cater for a normal displacement of the cockpit corresponding to the outer main gear wheel on the taxiway edge.

2. See collective notes for Figures C1-12 to C1-21.
Figure C1-19. Isocandela diagram for high-intensity taxiway centre line (7.5 m spacing) and stop bar lights in curved sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required.
Notes:
1. Although the lights flash in normal operation, the light intensity is specified as if the lights were fixed for incandescent lamps.
2. See collective notes for Figures C1-12 to C1-21.

Figure C1-20. Isocandela diagram for high-intensity runway guard lights, Configuration B

Figure C1-21. Grid points to be used for calculation of average intensity of taxiway centre line and stop bar lights
Collective notes to Figures C1-12 to C1-21

1. The intensities specified in Figures C1-12 to C1-20 are in green and yellow light for taxiway centre line lights, yellow light for runway guard lights and red light for stop bar lights.

2. Figures C1-12 to C1-20 show the minimum allowable light intensities. The average intensity of the main beam is calculated by establishing grid points as shown in Figure C1-21 and using the intensity values measured at all grid points located within and on the perimeter of the rectangle representing the main beam. The average value is the arithmetic average of the light intensities measured at all considered grid points.

3. No deviations are acceptable in the main beam or in the innermost beam, as applicable, when the lighting fixture is properly aimed.

4. Horizontal angles are measured with respect to the vertical plane through the taxiway centre line except on curves where they are measured with respect to the tangent to the curve.

5. Vertical angles are measured from the longitudinal slope of the taxiway surface.

6. The importance of adequate maintenance cannot be overemphasized. The intensity, either average where applicable or as specified on the corresponding iso candela curves, should never fall to a value less than 50 per cent of the value shown in the figures, and it should be the aim of airport authorities to maintain a level of light output close to the specified minimum average intensity.

7. The light unit shall be installed so that the main beam or the innermost beam, as applicable, is aligned within one half degree of the specified requirement.
Figure C1-22. Light intensity distribution of T-VASIS and AT-VASIS
Figure C1-23. Light intensity distribution of PAPI and APAPI
Notes:

1. Although the lights flash in normal operation, the light intensity is specified as if the lights were fixed for incandescent lamps.

2. The intensities specified are in yellow light.

Figure C1-24. Isocandela diagram for each light in low-intensity runway guard lights, Configuration A
Notes:

1. Although the lights flash in normal operation, the light intensity is specified as if the lights were fixed for incandescent lamps.

2. The intensities specified are in yellow light.

Figure C1-25. Isocandela diagram for each light in high-intensity runway guard lights, Configuration A
## Table D1-1. Secondary power supply requirements (see 10.1.5)

<table>
<thead>
<tr>
<th>Runway</th>
<th>Lighting aids requiring power</th>
<th>Maximum switch-over time</th>
</tr>
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<tbody>
<tr>
<td>Non-instrument</td>
<td>Visual approach slope indicators&lt;sup&gt;a&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Runway edge&lt;sup&gt;b&lt;/sup&gt;</td>
<td>10.1.5 and 10.1.10</td>
</tr>
<tr>
<td></td>
<td>Runway threshold&lt;sup&gt;c&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Runway end&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstacle&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Non-precision approach</td>
<td>Approach lighting system</td>
<td>15 seconds</td>
</tr>
<tr>
<td></td>
<td>Visual approach slope indicators&lt;sup&gt;h&lt;/sup&gt;&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Runway edge&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Runway threshold&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Runway end</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Obstacle&lt;sup&gt;e&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>Precision approach category 1</td>
<td>Approach lighting system</td>
<td>15 seconds</td>
</tr>
<tr>
<td></td>
<td>Runway edge&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
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<tr>
<td></td>
<td>Visual approach slope indicators&lt;sup&gt;h&lt;/sup&gt;&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
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<tr>
<td></td>
<td>Runway threshold&lt;sup&gt;d&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Runway end</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Essential taxiway&lt;sup&gt;g&lt;/sup&gt;</td>
<td>15 seconds</td>
</tr>
<tr>
<td></td>
<td>Obstacle&lt;sup&gt;e&lt;/sup&gt;</td>
<td>15 seconds</td>
</tr>
<tr>
<td>Precision approach category IV/III</td>
<td>Inner 300 m of the approach lighting system</td>
<td>1 second</td>
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<tr>
<td></td>
<td>Other parts of the approach lighting system</td>
<td>15 seconds</td>
</tr>
<tr>
<td></td>
<td>Obstacle&lt;sup&gt;e&lt;/sup&gt;</td>
<td>15 seconds</td>
</tr>
<tr>
<td></td>
<td>Runway edge</td>
<td>15 seconds</td>
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<tr>
<td></td>
<td>Runway threshold</td>
<td>1 second</td>
</tr>
<tr>
<td></td>
<td>Runway end</td>
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<tr>
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</tr>
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<td></td>
<td>All stop bars</td>
<td>1 second</td>
</tr>
<tr>
<td></td>
<td>Essential taxiway&lt;sup&gt;g&lt;/sup&gt;</td>
<td>15 seconds</td>
</tr>
<tr>
<td></td>
<td>Obstacle&lt;sup&gt;e&lt;/sup&gt;</td>
<td>15 seconds</td>
</tr>
</tbody>
</table>

Runway meant for take-off in runway visual range conditions less than a value of 800 m:

- Runway edge: 15 seconds<sup>d</sup>
- Runway end: 1 second
- Runway centre line: 1 second
- All stop bars: 1 second
- Essential taxiway<sup>g</sup>: 15 seconds
- Obstacle<sup>e</sup>: 15 seconds

---

a. Supplied with secondary power when their operation is essential to the safety of flight operation.
b. See Chapter 5, 5.3.2, regarding the use of emergency lighting.
c. One second where no runway centre line lights are provided.
d. One second where approaches are over hazardous or precipitous terrain.
1. **Intensity control of approach and runway lights**

1.1 The conspicuity of a light depends on the impression received of contrast between the light and its background. If a light is to be useful to a pilot by day when on approach, it must have an intensity of at least 2,000 or 3,000 cd, and in the case of approach lights an intensity of the order of 20,000 cd is desirable. In conditions of very bright daylight fog it may not be possible to provide lights of sufficient intensity to be effective. On the other hand, in clear weather on a dark night, an intensity of the order of 100 cd for approach lights and 50 cd for the runway edge lights may be found suitable. Even then, owing to the closer range at which they are viewed, pilots have sometimes complained that the runway edge lights seemed unduly bright.

1.2 In fog the amount of light scattered is high. At night this scattered light increases the brightness of the fog over the approach area and runway to the extent that little increase in the visual range of the lights can be obtained by increasing their intensity beyond 2,000 or 3,000 cd. In an endeavor to increase the range at which lights would first be sighted at night, their intensity must not be raised to an extent that a pilot might find excessively dazzling at diminished range.

1.3 From the foregoing will be evident the importance of adjusting the intensity of the lights of an aerodrome lighting system according to the prevailing conditions, so as to obtain the best results without excessive dazzle that would disconcert the pilot. The appropriate intensity setting on any particular occasion will depend both on the conditions of background brightness and the visibility. Detailed guidance material on selecting intensity setting for different conditions is given in the *Aerodrome Design Manual* (Doc 9157), Part 4.

2. **Approach lighting systems**

2.1 Types and characteristics

2.1.1 The specifications in this volume provide for the basic characteristics for simple and precision approach lighting systems. For certain aspects of these systems, some latitude is permitted, for example, in the spacing between centre line lights and crossbars. The approach lighting patterns that have been generally adopted are shown in Figures A-1 and A-2. A diagram of the inner 300 m of the precision approach category II and III lighting system is shown in Appendix A, Figure A1-4.

2.1.2 The approach lighting configuration is to be provided irrespective of the location of the threshold, i.e. whether the threshold is at the extremity of the runway or displaced from the runway extremity. In both cases, the approach lighting system should extend up to the threshold. However, in the case of a displaced threshold, inset lights are used from the runway extremity up to the threshold to obtain the specified configuration. These inset lights are designed to satisfy the structural requirements specified in 9.1.9, and the photometric requirements specified in Appendix C, Figure C1-1 or C1-2.

2.1.3 Flight path envelopes to be used in designing the lighting are shown in Figure A-4.

2.2 Installation tolerances

**Horizontal**

2.2.1 The dimensional tolerances are shown in Figure A-2.
2.2.2 The centre line of an approach lighting system should be as coincident as possible with the extended centre line of the runway with a maximum tolerance of ±15′.

2.2.3 The longitudinal spacing of the centre line lights should be such that one light (or group of lights) is located in the centre of each crossbar, and the intervening centre line lights are spaced as evenly as practicable between two crossbars or a crossbar and a threshold.

2.2.4 The crossbars and barrettes should be at right angles to the centre line of the approach lighting system with a tolerance of ±30′, if the pattern in Figure A-2 (A) is adopted or ± 2°, if Figure A-2 (B) is adopted.

2.2.5 When a crossbar has to be displaced from its standard position, any adjacent crossbar should, where possible, be displaced by appropriate amounts in order to reduce the differences in the crossbar spacing.

2.2.6 When a crossbar in the system shown in Figure A-2 (A) is displaced from its standard position, its overall length should be adjusted so that it remains one-twentieth of the actual distance of the crossbar from the point of origin. It is not necessary, however, to adjust the standard 2.7 m spacing between the crossbar lights, but the crossbars should be kept symmetrical about the centre line of the approach lighting.

Vertical

2.2.7 The ideal arrangement is to mount all the approach lights in the horizontal plane passing through the threshold (see Figure A-3), and this should be the general aim as far as local conditions permit. However, buildings, trees, etc., should not obscure the lights from the view of a pilot who is assumed to be 1° below the electronic glide path in the vicinity of the outer marker.

2.2.8 Within a stopway or clearway, and within 150 m of the end of a runway, the lights should be mounted as near to the ground as local conditions permit in order to minimize risk of damage to aeroplanes in the event of an overrun or undershoot. Beyond the stopway and clearway, it is not so necessary for the lights to be mounted close to the ground, and therefore undulations in the ground contours can be compensated for by mounting the lights on poles of appropriate height.

2.2.9 It is desirable that the lights be mounted so that, as far as possible, no object within a distance of 60 m on each side of the centre line protrudes through the plane of the approach lighting system. Where a tall object exists within 60 m of the centre line and within 1 350 m from the threshold for a precision approach lighting system, or 900 m for a simple approach lighting system, it may be advisable to install the lights so that the plane of the outer half of the pattern clears the top of the object.

2.2.10 In order to avoid giving a misleading impression of the plane of the ground, the lights should not be mounted below a gradient of 1 in 66 downwards from the threshold to a point 300 m out, and below a gradient of 1 in 40 beyond the 300 m point. For a precision approach category II and III lighting system, more stringent criteria may be necessary, e.g. negative slopes not permitted within 450 m of the threshold.

2.2.11 Centre line. The gradients of the centre line in any section (including a stopway or clearway) should be as small as practicable, and the changes in gradients should be as few and small as can be arranged and should not exceed 1 in 60. Experience has shown that as one
proceeds outwards from the runway, rising gradients in any section of up to 1 in 66, and falling gradients of down to 1 in 40, are acceptable.

2.2.12 **Crossbars.** The crossbar lights should be so arranged as to lie on a straight line passing through the associated centre line lights, and wherever possible this line should be horizontal. It is permissible, however, to mount the lights on a transverse gradient not more than 1 in 80, if this enables crossbar lights within a stopway or clearway to be mounted nearer to the ground on sites where there is a cross-fall.

2.3 Clearance of obstacles

2.3.1 An area, hereinafter referred to as the light plane, has been established for obstacle clearance purposes, and all lights of the system are in this plane. This plane is rectangular in shape and symmetrically located about the approach lighting system's centre line. It starts at the threshold and extends 60 m beyond the approach end of the system, and is 120 m wide.

2.3.2 No objects are permitted to exist within the boundaries of the light plane which are higher than the light plane except as designated herein. All roads and highways are considered as obstacles extending 4.8 m above the crown of the road, except aerodrome service roads where all vehicular traffic is under control of the aerodrome authorities and coordinated with the aerodrome traffic control tower. Railroads, regardless of the amount of traffic, are considered as obstacles extending 5.4 m above the top of the rails.

2.3.3 It is recognized that some components of electronic landing aids systems, such as reflectors, antennas, monitors, etc., must be installed above the light plane. Every effort should be made to relocate such components outside the boundaries of the light plane. In the case of reflectors and monitors, this can be done in many instances.

2.3.4 Where an ILS localizer is installed within the light plane boundaries, it is recognized that the localizer, or screen if used, must extend above the light plane. In such cases the height of these structures should be held to a minimum and they should be located as far from the threshold as possible. In general the rule regarding permissible heights is 15 cm for each 30 m the structure is located from the threshold. As an example, if the localizer is located 300 m from the threshold, the screen will be permitted to extend above the plane of the approach lighting system by 10 × 15 = 150 cm maximum, but preferably should be kept as low as possible consistent with proper operation of the ILS.

2.3.5 In locating an MLS azimuth antenna the guidance contained in Annex 10, Volume I, Attachment G, should be followed. This material, which also provides guidance on collocating an MLS azimuth antenna with an ILS localizer antenna, suggests that the MLS azimuth antenna may be sited within the light plane boundaries where it is not possible or practical to locate it beyond the outer end of the approach lighting for the opposite direction of approach. If the MLS azimuth antenna is located on the extended centre line of the runway, it should be as far as possible from the closest light position to the MLS azimuth antenna in the direction of the runway end. Furthermore, the MLS azimuth antenna phase centre should be at least 0.3 m above the light centre of the light position closest to the MLS azimuth antenna in the direction of the runway end. (This could be relaxed to 0.15 m if the site is otherwise free of significant multipath problems.) Compliance with this requirement, which is intended to ensure that the MLS signal quality is not affected by the approach lighting system, could result in the partial obstruction of the lighting system by the MLS azimuth antenna. To ensure that the resulting obstruction does not degrade visual guidance beyond
an acceptable level, the MLS azimuth antenna should not be located closer to the runway end than 300 m and the preferred location is 25 m beyond the 300 m crossbar (this would place the antenna 5 m behind the light position 330 m from the runway end). Where an MLS azimuth antenna is so located, a central part of the 300 m crossbar of the approach lighting system would alone be partially obstructed. Nevertheless, it is important to ensure that the unobstructed lights of the crossbar remain serviceable all the time.

2.3.6 Objects existing within the boundaries of the light plane, requiring the light plane to be raised in order to meet the criteria contained herein, should be removed, lowered or relocated where this can be accomplished more economically than raising the light plane.

2.3.7 In some instances objects may exist which cannot be removed, lowered or relocated economically. These objects may be located so close to the threshold that they cannot be cleared by the 2 per cent slope. Where such conditions exist and no alternative is possible, the 2 per cent slope may be exceeded or a “stair step” resorted to in order to keep the approach lights above the objects. Such “step” or increased gradients should be resorted to only when it is impracticable to follow standard slope criteria, and they should be held to the absolute minimum. Under this criterion no negative slope is permitted in the outermost portion of the system.

2.4 Consideration of the effects of reduced lengths

2.4.1 The need for an adequate approach lighting system to support precision approaches where the pilot is required to acquire visual references prior to landing cannot be stressed too strongly. The safety and regularity of such operations is dependent on this visual acquisition. The height above runway threshold at which the pilot decides there are sufficient visual cues to continue the precision approach and land will vary, depending on the type of approach being conducted and other factors such as meteorological conditions, ground and airborne equipment, etc. The required length of approach lighting system which will support all the variations of such approaches is 900 m, and this shall always be provided whenever possible.

2.4.2 However, there are some runway locations where it is impossible to provide the 900 m length of approach lighting system to support precision approaches.

2.4.3 In such cases, every effort should be made to provide as much approach lighting system as possible. The appropriate authority may impose restrictions on operations to runways equipped with reduced lengths of lighting. There are many factors which determine at what height the pilot must have decided to continue the approach to land or execute a missed approach. It must be understood that the pilot does not make an instantaneous judgment upon reaching a specified height. The actual decision to continue the approach and landing sequence is an accumulative process which is only concluded at the specified height. Unless lights are available prior to reaching the decision point, the visual assessment process is impaired and the likelihood of missed approaches will increase substantially. There are many operational considerations which must be taken into account by the appropriate authorities in deciding if any restrictions are necessary to any precision approach and these are detailed in Annex 6.
3. **Priority of installation of visual approach slope indicator systems**

3.1 It has been found impracticable to develop guidance material that will permit a completely installation of a visual approach slope indicator system. However, factors that must be considered when making such a decision are:

- (a) frequency of use;
- (b) seriousness of the hazard;
- (c) presence of other visual and non-visual aids;
- (d) type of aeroplanes using the runway; and
- (e) frequency and type of adverse weather conditions under which the runway will be used.

3.2 With respect to the seriousness of the hazard, the order given in the application specifications for a visual approach slope indicator system, 9.5.1 b) to e), may be used as a general guide. These may be summarized as:

- (a) inadequate visual guidance because of:
  - (1) approaches over water or featureless terrain, or absence of sufficient extraneous light in the approach area by night;
  - (2) deceptive surrounding terrain;
- (b) serious hazard in approach;
- (c) serious hazard if aeroplanes undershoot or overrun; and
- (d) unusual turbulence.

3.3 The presence of other visual or non-visual aids is a very important factor. Runways equipped with ILS or MLS would generally receive the lowest priority for a visual approach slope indicator system installation. It must be remembered, though, that visual approach slope indicator systems are visual approach aids in their own right and can supplement electronic aids. When serious hazards exist and/or a substantial number of aeroplanes not equipped for ILS or MLS use a runway, priority might be given to installing a visual approach slope indicator on this runway.

3.4 Priority should be given to runways used by turbojet aeroplanes.

4. **Rapid exit taxiway indicator lights**

4.1 Rapid exit taxiway indicator lights (RETILs) comprise a set of yellow unidirectional lights installed in the runway adjacent to the centre line. The lights are positioned in a 3-2-1 sequence at 100 m intervals prior to the point of tangency of the rapid exit taxiway centre line. They are intended to give an indication to pilots of the location of the next available rapid exit taxiway.
4.2 In low visibility conditions, RETILs provide useful situational awareness cues while allowing the pilot to concentrate on keeping the aircraft on the runway centre line.

4.3 Following a landing, runway occupancy time has a significant effect on achievable runway capacity. RETILs allow pilots to maintain a good roll-out speed until it is necessary to decelerate to an appropriate speed for the turn into a rapid exit turn-off. A roll-out speed of 60 knots until the first RETIL (three-light barrette) is reached is seen as the optimum.

5. Lighting of unserviceable areas

Where a temporarily unserviceable area exists, it may be marked with fixed-red lights. These lights should mark the most potentially dangerous extremities of the area. A minimum of four such lights should be used, except where the area is triangular in shape where a minimum of three lights may be employed. The number of lights should be increased when the area is large or of unusual configuration. At least one light should be installed for each 7.5 m of peripheral distance of the area. If the lights are directional, they should be orientated so that as far as possible their beams are aligned in the direction from which aircraft or vehicles will approach. Where aircraft or vehicles will normally approach from several directions, consideration should be given to adding extra lights or using Omni directional lights to show the area from these directions. Unsuitable area lights should be frangible. Their height should be sufficiently low to preserve clearance for propellers and for engine pods of jet aircraft.
Figure A-1. Simple Approach lighting systems
Figure A-2. Precision approach category I lighting systems
Figure A-3. Vertical installation tolerance
Figure A-4. Flight path envelopes to be used for lighting design for category I, II and III operations
1. Colours for aeronautical ground lights

1.1 Chromaticities

1.1.1 The chromaticities of aeronautical ground lights shall be within the following boundaries: CIE Equations (see Figure A1-1):

(a) Red
   Purple boundary \( y = 0.980 - x \)
   Yellow boundary \( y = 0.335 \)

(b) Yellow
   Red boundary \( y = 0.382 \)
   White boundary \( y = 0.790 - 0.667x \)
   Green boundary \( y = x - 0.120 \)

(c) Green
   Yellow boundary \( x = 0.360 - 0.080y \)
   White boundary \( x = 0.650y \)
   Blue boundary \( y = 0.390 - 0.171x \)

(d) Blue
   Green boundary \( y = 0.805x + 0.065 \)
   White boundary \( y = 0.400 - x \)
   Purple boundary \( x = 0.600y + 0.133 \)

(e) White
   Yellow boundary \( x = 0.500 \)
   Blue boundary \( x = 0.285 \)
   Green boundary \( y = 0.440 \)
   and \( y = 0.150 + 0.640x \)
   Purple boundary \( y = 0.050 + 0.750x \)
   and \( y = 0.382 \)

(f) Variable white
   Yellow boundary \( x = 0.255 + 0.750y \)
   and \( x = 1.185 - 1.500y \)
   Blue boundary \( x = 0.285 \)
   Green boundary \( y = 0.440 \)
   and \( y = 0.150 + 0.640x \)
   Purple boundary \( y = 0.050 + 0.750x \)
   and \( y = 0.382 \)

Note.— Guidance on chromaticity changes resulting from the effect of temperature on filtering elements is given in the Aerodrome Design Manual (Doc 9157), Part 4.

1.1.2 Where dimming is not required, or where observers with defective colour vision must be able to determine the colour of the light, green signals should be within the following boundaries:
   Yellow boundary \( y = 0.726 - 0.726x \)
   White boundary \( x = 0.650y \)
   Blue boundary \( y = 0.390 - 0.171x \)

1.1.3 Where increased certainty of recognition is more important than maximum visual range, green signals should be within the following boundaries:
ATTACHMENT 2 – COLOURS FOR AERONAUTICAL GROUND LIGHTS

Yellow boundary \( y = 0.726 - 0.726x \)
White boundary \( x = 0.625y - 0.041 \)
Blue boundary \( y = 0.390 - 0.171x \)

1.2 Discrimination between lights

1.2.1 If there is a requirement to discriminate yellow and white from each other, they should be displayed in close proximity of time or space as, for example, by being flashed successively from the same beacon.

1.2.2 If there is a requirement to discriminate yellow from green and/or white, as for example on exit taxiway centre line lights, the \( y \) coordinates of the yellow light should not exceed a value of 0.40.

Note.— *The limits of white have been based on the assumption that they will be used in situations in which the characteristics (colour temperature) of the light source will be substantially constant.*

1.2.3 The colour variable white is intended to be used only for lights that are to be varied in intensity, e.g. to avoid dazzling. If this colour is to be discriminated from yellow, the lights should be so designed and operated that:

(a) the \( x \) coordinate of the yellow is at least 0.050 greater than the \( x \) coordinate of the white; and

(b) the disposition of the lights will be such that the yellow lights are displayed simultaneously and in close proximity to the white lights.

1.2.4 The colour of aeronautical ground lights shall be verified as being within the boundaries specified in Figure ATT 1-1 by measurement at five points within the area limited by the innermost isocandela curve (isocandela diagrams in Appendix C refer), with operation at rated current or voltage. In the case of elliptical or circular isocandela curves, the colour measurements shall be taken at the centre and at the horizontal and vertical limits. In the case of rectangular isocandela curves, the colour measurements shall be taken at the centre and the limits of the diagonals (corners). In addition, the colour of the light shall be checked at the outermost isocandela curve to ensure that there is no colour shift that might cause signal confusion to the pilot.

*Note 1.— For the outermost isocandela curve, a measurement of colour coordinates should be made and recorded for review and judgement of acceptability by the appropriate authority.*

*Note 2.— Certain light units may have application so that they may be viewed and used by pilots from directions beyond that of the outermost isocandela curve (e.g. stop bar lights at significantly wide runway-holding positions). In such instances, the appropriate authority should assess the actual application and if necessary require a check of colour shift at angular ranges beyond the outermost curve.*

1.2.5 In the case of visual approach slope indicators and other light units having a colour transition sector, the colour shall be measured at points in accordance with 1.2.4, except that the colour areas shall be treated separately and no point shall be within 0.5 degrees of the transition sector.
Figure ATT 1-1. Colours for aeronautical ground lights