AC 139-4-2 (Rev 1)
5 August 2025

Civil Aviation Authority of Singapore

Advisory Circular

RECOMMENDED PRACTICES FOR AERODROMES

GENERAL

Advisory Circulars (ACs) are issued by the Director-General of Civil Aviation (DGCA) from time to time to provide practical guidance or certainty in respect of the statutory requirements for aviation safety. ACs contain information about standards, practices and procedures acceptable to CAAS. An AC may be used, in accordance with section 11 of the Air Navigation Act 1966 (ANA), to demonstrate compliance with a statutory requirement. The revision number of the AC is indicated in parenthesis in the suffix of the AC number.

PURPOSE

This AC provides guidance and information on compliance to the requirements in Aviation Specification 5 – Aerodromes (AS-5) regarding the design, operations, maintenance of, and modifications to the aerodrome and recommended practices to which an aerodrome operator should endeavour to conform with.

APPLICABILITY

This AC is applicable to an aerodrome operator who intends to or holds an aerodrome certificate.

RELATED REGULATIONS
This AC relates specifically to Regulations 19 and 42 of the ANR-139.

RELATED ADVISORY CIRCULAR
AC 139-2-1 Guidance on aerodrome manual or heliport manual
AC 139-4-4 Use of pavement under overload operations
AC 139-4-5 Guidance on development works and modification at the aerodrome
AC 139-5-4 Guidance on obstacle restriction and removal

CANCELLATION
This AC supersedes AC 139-4-2(0) dated 1 March 2023. This revision updates the guidance relating to Chapters 6, 7, 8 and 12 of AS-5 (Rev 2), particularly the replacement of the guidance relating to Chapter 7 of AS-5 on Obstacle Restriction and Removal.

EFFECTIVE DATE
This AC is effective from 5 August 2025.

OTHER REFERENCES
- Aviation Specifications 5 - Aerodromes
- ICAO Annex 14 Vol. I Aerodromes Design and Operations
- ICAO PANS Aerodromes (Doc 9981)
- ICAO PANS Aeronautical Information Management (Doc 10066)
- ICAO Aerodrome Design Manual (Doc 9157)
- ICAO Airport Planning Manual (Doc 9184)

1 RECOMMENDED PRACTICES FOR THE AERODROME

1.1 Subparagraph (1)(a) of Regulation 19 in the ANR-139 requires that an aerodrome operator ensure that the design, operations and maintenance of, and any modifications to, the aerodrome comply with the design, operations and maintenance requirements specified in the relevant Aviation Specifications.

1.2 For an aerodrome with runways, the aerodrome operator must comply with the requirements in the Aviation Specifications 5 – Aerodromes (AS-5) and should follow the related guidance provided in this AC, in the design, operations and maintenance of, and any modifications to the aerodrome. The aerodrome operator should endeavour to implement the recommended practices (RP) in this AC and inform CAAS on the status and assessment of their implementation.

1.3 This AC should be read in conjunction with AS-5.

2 GUIDANCE FOR CHAPTER 4 OF AS-5: AERODROME REFERENCE CODE

2.1 The reference code is to provide a simple method for inter-relating the numerous specifications concerning the characteristics of aerodromes. This provides a series of aerodrome facilities that are suitable for aeroplanes that are intended to operate at the aerodrome. The code is not intended to be used for determining runway length or pavement strength requirements. The code is composed of two elements which are related to the aeroplane performance characteristics and dimensions. Element 1 is a number based on the aeroplane reference field length and element 2 is a letter based on the aeroplane wingspan. The code letter or number within an element

selected for design purposes is related to the critical aeroplane characteristics for which the facility is provided.

2.2 Provisions for the accommodation of more demanding aircraft at existing aerodromes can be found in the PANS-Aerodromes (Doc 9981). Guidance on some possible effects of future aircraft on these specifications is given in the Aerodrome Design Manual (Doc 9157), Part 2.

2.3 Procedures to assess the compatibility of the operation of a new aeroplane with an existing aerodrome can be found in the PANS-Aerodromes (Doc 9981).

2.4 Regulation 42 of ANR-139 provides for the aerodrome operator to allow an aeroplane that exceeds the aerodrome reference code to operate at the aerodrome if certain requirements are met. These requirements include the development and implementation of appropriate measures to maintain an acceptable level of safety during the operations of the aeroplane and notify the relevant aerodrome users and service providers affected by the operations of the aeroplane. The aerodrome operator should refer to PANS-AIM (Doc 10066), Appendix 2, AD 2.20, on the provision of a detailed description of traffic regulations, and PANS-Aerodromes (Doc 9981), Chapter 3, section 3.6, on promulgation of safety information for such intended operations.

Airport design

2.5 The design of an aerodrome should take into account land-use and environmental control measures. Guidance on land-use planning and environmental control measures is contained in the Airport Planning Manual (Doc 9184), Part 2.

3 GUIDANCE FOR CHAPTER 5 OF AS-5: AERODROME RELATED DATA

3.1 Aeronautical data

3.1.1 Aerodrome mapping data should be made available to the Aeronautical Information Services (AIS) where safety and/or performance-based operations suggest possible benefits.

3.1.2 Aerodrome mapping databases related provisions are contained in Annex 15, Chapter 5 and PANS-AIM (Doc 10066), Chapter 5.

3.1.3 Guidance material concerning the application of aerodrome mapping databases is provided in ICAO Annex 14, Vol. I Attachment A, Section 22.

3.2 Aerodrome reference temperature

3.2.1 The aerodrome reference temperature should be the monthly mean of the daily maximum temperatures for the hottest month of the year (the hottest month being that which has the highest monthly mean temperature). This temperature should be averaged over a period of years.

3.3 Strength of pavements

3.3.1 ICAO Aerodrome Design Manual (Doc 9157) Part 3 includes the descriptions of more detailed procedures for evaluation of pavements and their suitability for restricted overload operations.

3.4 Pre-flight altimeter check location

3.4.1 A pre-flight check location should be located on an apron.

3.4.2 Locating a pre-flight altimeter location on an apron enables an altimeter check to be made prior to obtaining taxi clearance and eliminates the need for stopping for that purpose after leaving the apron.

3.4.3 Normally an entire apron can serve as a satisfactory altimeter check location.

3.5 Declared distances

3.5.1 Where a runway is not provided with a stopway or clearway and the threshold is located at the extremity of the runway, the four declared distances should normally be equal to the length of the runway, as shown in AS-5 Figure 5-1 (A).

3.5.2 If a runway direction cannot be used for take-off or landing, or both, because it is operationally forbidden, then this should be declared and the words “not usable” or the abbreviation “NU” entered, as shown in AS-5 Figure 5-1.

3.6 Runway surface condition for use in the runway condition report

3.6.1 ICAO Annex 14 Attachment A, Section 6 provides details on the pertinent information that should be taken into consideration for the runway surface condition assessment. ICAO PANS-Aerodromes (Doc 9981) should also be referred to for procedures on the use of the runway condition report and assignment of the RWYCC in accordance with the runway condition assessment matrix (RCAM).

3.6.2 Friction measurements made on runway surface conditions with contaminants should not be reported as part of the overall runway surface assessment.

3.7 Disabled aircraft removal

3.7.1 Information concerning the capability to remove an aircraft disabled on or adjacent to the movement area should be made available.

3.7.2 The capability to remove a disabled aircraft may be expressed in terms of the largest type of aircraft which the aerodrome is equipped to remove.

4 GUIDANCE FOR CHAPTER 6 OF AS-5: PHYSICAL CHARACTERISTICS

4.1 This chapter in the AS-5 contains specifications related to the physical characteristics that are required of an aerodrome runway, taxiway, apron and related facilities.

4.2 Runways

Number and orientation of runways

4.2.1 Many factors affect the determination of the orientation, siting and number of runways. One important factor is the usability factor, as determined by the wind distribution, which is specified hereunder. Another important factor is the alignment of the runway to facilitate the provision of approaches conforming to the approach surface specifications in Chapter 7 of AS-5. In ICAO Annex 14 Vol. I, Attachment A, Section 1, information is given concerning these and other factors.

4.2.2 When a new instrument runway is being located, particular attention needs to be given to areas over which aeroplanes will be required to fly when following instrument approach and missed approach procedures, so as to ensure that obstacles in these areas or other factors will not restrict the operation of the aeroplanes for which the runway is intended.

4.2.3 The number and orientation of runways at an aerodrome should be such that the usability factor of the aerodrome is not less than 95 per cent for the aeroplanes that the aerodrome is intended to serve.

4.2.4 The siting and orientation of runways at an aerodrome should, where possible, be such that the arrival and departure tracks minimise interference with areas approved for residential use and other noise sensitive areas close to the aerodrome in order to avoid future noise problems.

4.2.5 Guidance on how to address noise problems is provided in the ICAO Airport Planning Manual (Doc 9184) Part 2 and in the ICAO Guidance on the Balanced Approach to Aircraft Noise Management (Doc 9829).

Choice of maximum permissible cross-wind components

4.2.6 In the application of paragraph 4.2.3, it should be assumed that landing or take-off of aeroplanes is, in normal circumstances, precluded when the cross-wind component exceeds:

(a) 37 km/h (20 kt): in the case of aeroplanes whose reference field length is 1 500 m or over, except that when poor runway braking action owing to an insufficient longitudinal coefficient of friction is experienced with some frequency, a cross-wind component not exceeding 24 km/h (13 kt) should be assumed;
(b) 24 km/h (13 kt): in the case of aeroplanes whose reference field length is 1 200 m or up to but not including 1 500 m; and
(c) 19 km/h (10 kt): in the case of aeroplanes whose reference field length is less than 1 200 m.

4.2.7 In ICAO Annex 14 Vol. I, Attachment A, Section 1, guidance is given on factors affecting the calculation of the estimate of the usability factor and allowances which may have to be made to take account of the effect of unusual circumstances.

Data to be used

4.2.8 The selection of data to be used for the calculation of the usability factor should be based on reliable wind distribution statistics that extend over as long a period as possible, preferably of not less than five years. The observations used should be made at least eight times daily and spaced at equal intervals of time.

4.2.9 These winds speed are mean speeds of the winds. Reference to the need for some allowance for gusty conditions is made in ICAO Annex 14 Vol. I, Attachment A, Section 1.

Location of threshold

4.2.10 A threshold should normally be located at the extremity of a runway unless operational considerations justify the choice of another location.

4.2.11 Guidance on the siting of the threshold is given in ICAO Annex 14 Vol. I, Attachment A, Section 10.

4.2.12 When it is necessary to displace a threshold, either permanently or temporarily, from its normal location, account should be taken of the various factors which may have a bearing on the location of the threshold. Where this displacement is due to an unserviceable runway condition, a cleared and graded area of at least 60 m in length should be available between the unserviceable area and the displaced threshold. Additional distance should also be provided to meet the requirements of the runway end safety area as appropriate.

4.2.13 Guidance on factors which may be considered in the determination of the location of a displaced threshold is given in ICAO Annex 14 Vol. I, Attachment A, Section 10.

Actual length of runways

Primary runway

4.2.14 Except as provided in paragraph 4.2.20, the actual runway length to be provided for a primary runway should be adequate to meet the operational requirements of the aeroplanes for which the runway is intended and should be not less than the longest length determined by applying the corrections for local conditions to the operations and performance characteristics of the relevant aeroplanes.

4.2.15 Paragraph 4.2.14 does not necessarily mean providing for operations by the critical aeroplane at its maximum mass.

4.2.16 Both take-off and landing requirements need to be considered when determining the length of runway to be provided and the need for operations to be conducted in both directions of the runway.

4.2.17 Local conditions that may need to be considered include elevation, temperature, runway slope, humidity and the runway surface characteristics.

4.2.18 When performance data on aeroplanes for which the runway is intended are not known, guidance on the determination of the actual length of a primary runway by application of general correction factors is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 1.

Secondary runway

4.2.19 The length of a secondary runway should be determined similarly to primary runways except that it needs only to be adequate for those aeroplanes which require to use that secondary runway in addition to the other runway or runways in order to obtain a usability factor of at least 95 per cent.

Runways with stopways or clearways

4.2.20 Where a runway is associated with a stopway or clearway, an actual runway length less than that resulting from application of paragraphs 4.2.14 or 4.2.19, as appropriate, may be considered satisfactory, but in such a case any combination of runway, stopway and clearway provided should permit compliance with the operational requirements for take-off and landing of the aeroplanes the runway is intended to serve.

4.2.21 Guidance on use of stopways and clearways is given in ICAO Annex 14 Vol. I, Attachment A, Section 2.

Transverse slopes

4.2.22 To promote the most rapid drainage of water, the runway surface should, if practicable, be cambered except where a single crossfall from high to low in the direction of the wind most frequently associated with rain would ensure rapid drainage. The transverse slope should ideally be:

— 1.5 per cent when the code letter is C, D, E or F; and
— 2 per cent when the code letter is A or B;

but in any event should not exceed 1.5 per cent or 2 per cent, as applicable, nor be less than 1 per cent except at runway or taxiway intersections where flatter slopes may be necessary.

4.2.23 For a cambered surface the transverse slope on each side of the centre line should be symmetrical.

4.2.24 On wet runways with cross-wind conditions the problem of aquaplaning from poor drainage is apt to be accentuated. Additional guidance is included in the ICAO Aerodrome Design Manual (Doc 9157), Parts 1 and 3.

Surface of runways

4.2.25 The surface of a paved runway should be evaluated when constructed or resurfaced to determine that the surface friction characteristics achieve the design objectives.

4.2.26 Additional guidance is included in the ICAO Airport Services Manual (Doc 9137), Part 2.

4.2.27 The average surface texture depth of a new surface should be not less than 1.0 mm.

4.2.28 Macrotexture and microtexture are taken into consideration in order to provide the required surface friction characteristics. Guidance on surface design is given in ICAO Annex 14, Vol. I, Attachment A, Section 8.

4.2.29 Guidance on methods used to measure surface texture is given in the ICAO Airport Services Manual (Doc 9137), Part 2.

4.2.30 Guidance on design and methods for improving surface texture is given in the Aerodrome Design Manual (Doc 9157), Part 3.

4.2.31 When the surface is grooved or scored, the grooves or scorings should be either perpendicular to the runway centre line or parallel to non-perpendicular transverse joints, where applicable.

4.2.32 Guidance on methods for improving the runway surface texture is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 3.

4.3 Runway shoulders

4.3.1 Guidance on characteristics and treatment of runway shoulders is given in ICAO Annex 14 Vol. I, Attachment A, Section 8, and in the ICAO Aerodrome Design Manual (Doc 9157), Part 1.

Width of runway shoulders

4.3.2 For aeroplanes with OMGWS from 9m up to but not including 15m, the runway shoulders should extend symmetrically on each side of the runway so that the overall width of the runway and its shoulders is not less than:

- 60m where the code letter is D or E;
- 60m where the code letter is F with two- or three-engined aeroplanes; and
- 75m where the code letter is F with four (or more)-engined aeroplanes.

Surface of runway shoulders

4.3.3 A runway shoulder should be prepared or constructed so as to resist erosion and the ingestion of the surface material by aeroplane engines.

4.3.4 Runway shoulders for code letter F aeroplanes should be paved to a minimum overall width of runway and shoulder of not less than 60m.

4.3.5 Guidance on surface of runway shoulders is given in the Aerodrome Design Manual, (Doc 9157), Part 1.

4.4 Runway turn pads

General

4.4.1 Where the end of a runway is not served by a taxiway or a taxiway turnaround and where the code letter is A, B or C, a runway turn pad should be provided to facilitate a 180-degree turn of aeroplanes.

4.4.2 Such areas may also be useful if provided along a runway to reduce taxiing time and distance for aeroplanes which may not require the full length of the runway.

4.4.3 Guidance on the design of the runway turn pads is available in ICAO Aerodrome Design Manual (Doc 9157), Part 1. Guidance on taxiway turnaround as an alternative facility is available in the ICAO Aerodrome Design Manual (Doc 9157), Part 2.

4.4.4 The runway turn pad may be located on either the left or right side of the runway and adjoining the runway pavement at both ends of the runway and at some intermediate locations, where deemed necessary.

4.4.5 The initiation of the turn would be facilitated by locating the turn pad on the left side of the runway, since the left seat is the normal position for the pilot-in-command.

4.4.6 The intersection angle of the runway turn pad with the runway should not exceed 30 degrees.

4.4.7 The nose wheel steering angle to be used in the design of the runway turn pad should not exceed 45 degrees.

Slopes on runway turn pads

4.4.8 The longitudinal and transverse slopes on a runway turn pad should be sufficient to prevent the accumulation of water on the surface and facilitate rapid drainage of surface water. The slopes should be the same as those on the adjacent runway pavement surface.

Strength of runway turn pads

4.4.9 The strength of a runway turn pad should be at least equal to that of the adjoining runway which it serves, due consideration being given to the fact that the turn pad will be subjected to slow-moving traffic making hard turns and consequent higher stresses to the pavement.

4.4.10 Where a runway turn pad is provided with flexible pavement, the surface would need to be capable of withstanding the horizontal shear forces exerted by the main landing gear tires during turning manoeuvres.

Surface of runway turn pads

4.4.11 The surface of a runway turn pad should be so constructed or resurfaced as to provide surface friction characteristics at least equal to that of the adjoining runway.

Shoulders of runway turn pads

4.4.12 The runway turn pads should be provided with shoulders of such width as is necessary to prevent surface erosion by the jet blast of the most demanding aeroplane for which the turn pad is intended, and any possible foreign object damage to the aeroplane engines.

4.4.13 As a minimum, the width of the shoulders would need to cover the outer engine of the most demanding aeroplane and thus may be wider than the associated runway shoulders.

4.4.14 The strength of runway turn pad shoulders should be capable of withstanding the occasional passage of the aeroplane it is designed to serve without inducing structural damage to the aeroplane and to the supporting ground vehicles that may operate on the shoulder.

4.5 Runway strips

Grading of runway strips

4.5.1 Where the areas in AS-5 paragraph 6.4.11 have paved surfaces, they should be able to withstand the occasional passage of the critical aeroplane for runway pavement design.

4.6 Runway end safety areas

4.6.1 A runway end safety area (RESA) should be provided at each end of a runway strip where the code number is 1 or 2 and the runway is a non-instrument one.

Dimensions of runway end safety areas

4.6.2 A runway end safety area should, as far as practicable, extend from the end of a runway strip to a distance of at least:

(a) 240 m where the code number is 3 or 4; or a reduced length when an arresting system is installed;
(b) 120 m where the code number is 1 or 2 and the runway is an instrument one; or a reduced length when an arresting system is installed; and
(c) 30 m where the code number is 1 or 2 and the runway is a non-instrument one.

4.6.3 Guidance on mitigating measures to reduce the probability and severity of aircraft undershooting or overrunning a runway at an aerodrome, where the RESA does not extend to the distances stated in paragraph 4.6.2 or AS-5 paragraph 6.5.2, is provided in **Appendix 1**.

4.6.4 The width of a runway end safety area should, wherever practicable, be equal to that of the graded portion of the associated runway strip.

4.7 Clearways

Width of clearways

4.7.1 A clearway should extend laterally on each side of the extended centre line of the runway, to a distance of at least:

(a) 75m for instrument runways; and
(b) half of the width of the runway strip for non-instrument runways.

4.8 Radio altimeter operating area

General

4.8.1 A radio altimeter operating area should be established in the pre-threshold area of a precision approach runway.

Width of the area

4.8.2 A radio altimeter operating area should extend laterally, on each side of the extended centre line of the runway, to a distance of 60m, except that, when special circumstances so warrant, the distance may be reduced to no less than 30m if an

aeronautical study indicates that such reduction would not affect the safety of operations of aircraft.

Longitudinal slope changes

4.8.3 On a radio altimeter operating area, slope changes should be avoided or kept to a minimum. Where slope changes cannot be avoided, the slope changes should be as gradual as practicable and abrupt changes or sudden reversals of slopes avoided. The rate of change between two consecutive slopes should not exceed 2 per cent per 30m.

4.8.4 Guidance on radio altimeter operating area is given in ICAO Annex 14 Vol. I, Attachment A, Section 4.3 and in the ICAO Manual of All-Weather Operations, (Doc 9365), Section 5.2. Guidance on the use of radio altimeter is given in the PANS-OPS, Volume II, Part II, Section 1.

4.9 Taxiways

4.9.1 Sufficient entrance and exit taxiways for a runway should be provided to expedite the movement of aeroplanes to and from the runway and provision of rapid exit taxiways considered when traffic volumes are high.

Taxiway curves

4.9.2 Changes in direction of taxiways should be as few and small as possible. The radii of the curves should be compatible with the manoeuvring capability and normal taxiing speeds of the aeroplanes for which the taxiway is intended. The design of the curve should be such that, when the cockpit of the aeroplane remains over the taxiway centre line markings, the clearance distance between the outer main wheels of the aeroplane and the edge of the taxiway should not be less than those specified in AS-5 paragraph 6.9.2.

4.9.3 An example of widening taxiways to achieve the wheel clearance specified is illustrated in Figure 4-1. Guidance on the values of suitable dimensions is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 2.

4.9.4 The location of taxiway centre line markings and lights is specified in paragraphs 6.2.7.4 and 6.3.16.11.

4.9.5 Compound curves may reduce or eliminate the need for extra taxiway width.

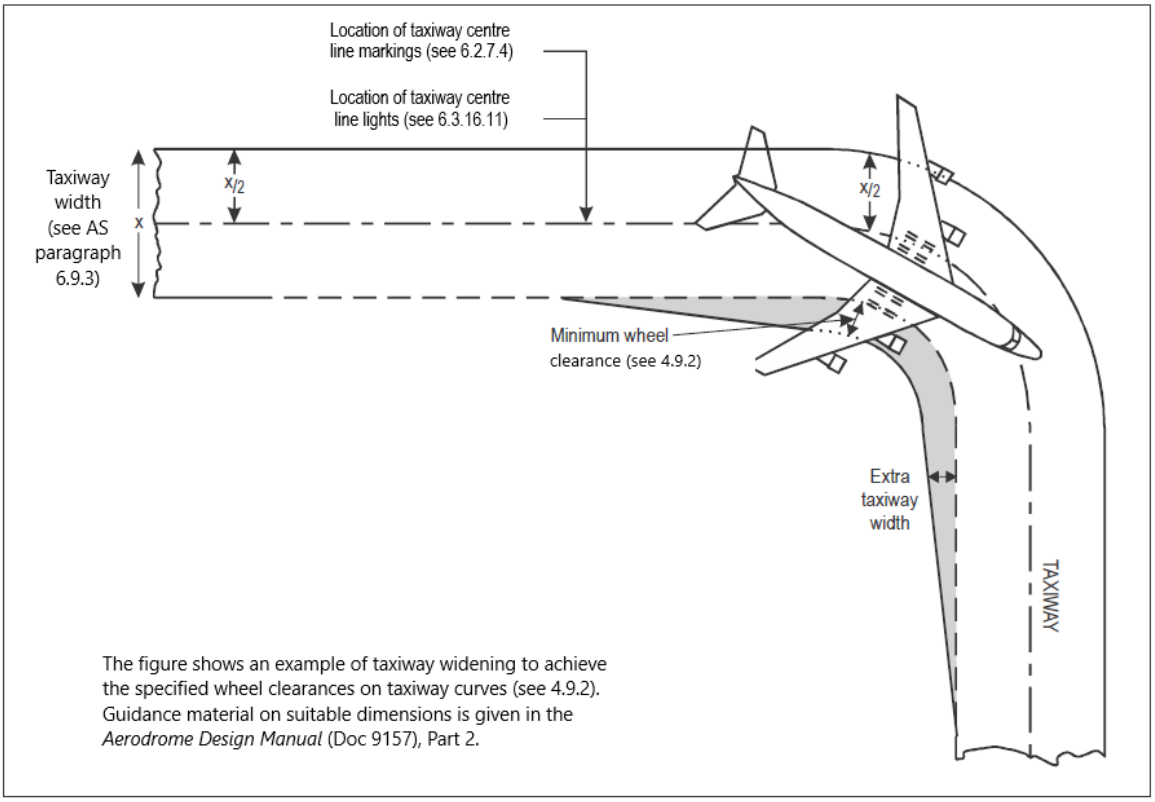

Figure 4-1. Taxiway curve

Junctions and intersections

4.9.6 To facilitate the movement of aeroplanes, fillets should be provided at junctions and intersections of taxiways with runways, aprons and other taxiways. The design of the fillets should ensure that the minimum wheel clearances specified in AS-5 paragraph 6.9.2 are maintained when aeroplanes are manoeuvring through the junctions or intersections.

4.9.7 Consideration will have to be given to the aeroplane datum length when designing fillets. Guidance on the design of fillets and the definition of the term aeroplane datum length are given in the ICAO Aerodrome Design Manual (Doc 9157), Part 2.

Surface of taxiways

4.9.8 The surface of a taxiway should not have irregularities that cause damage to aeroplane structures.

4.9.9 The surface of a paved taxiway should be so constructed as to provide suitable surface friction characteristics.

4.9.10 Suitable surface friction characteristics are those surface properties required on taxiways that assure safe operation of aeroplanes.

Rapid exit taxiways

4.9.11 The radius of the fillet on the inside of the curve at a rapid exit taxiway should be sufficient to provide a widened taxiway throat in order to facilitate early recognition of the entrance and turn-off onto the taxiway.

4.9.12 A rapid exit taxiway should include a straight distance after the turn-off curve sufficient for an exiting aircraft to come to a full stop clear of any intersecting taxiway.

4.9.13 The intersection angle of a rapid exit taxiway with the runway should not be greater than 45° nor less than 25° and preferably should be 30°.

4.10 Taxiway shoulders

4.10.1 Straight portions of a taxiway where the code letter is C, D, E or F should be provided with shoulders which extend symmetrically on each side of the taxiway so that the overall width of the taxiway and its shoulders on straight portions is not less than:

(a) 44m where the code letter is F;
(b) 38m where the code letter is E;
(c) 34m where the code letter is D; and
(d) 25m where the code letter is C.

4.10.2 On taxiway curves and on junctions or intersections where increased pavement is provided, the shoulder width should be not less than that on the adjacent straight portions of the taxiway.

4.11 Holding bays, runway-holding positions, intermediate holding positions and road-holding positions

General

4.11.1 Holding bay(s) should be provided when the traffic density is medium or heavy.

4.11.2 An intermediate holding position should be established on a taxiway at any point other than a runway-holding position where it is desirable to define a specific holding limit.

Location

4.11.3 At elevations greater than 700m (2 300 ft), the distance of 90m specified in AS-5 Table 6-2 for a precision approach runway code number 4 should be increased as follows:

(a) up to an elevation of 2 000m (6 600 ft); 1m for every 100m (330 ft) in excess of 700m (2 300 ft);
(b) elevation in excess of 2 000m (6 600 ft) and up to 4 000m (13 320 ft); 13m plus 1.5m for every 100m (330 ft) in excess of 2 000m (6 600 ft); and
(c) elevation in excess of 4 000m (13 320 ft) and up to 5 000m (16 650 ft); 43m plus 2m for every 100m (330 ft) in excess of 4 000m (13 320 ft).

4.11.4 If a holding bay, runway-holding position or road-holding position for a precision approach runway code number 4 is at a greater elevation compared to the threshold, the distance specified in AS-5 Table 6-2 should be further increased by 5m for every metre the bay or position is higher than the threshold.

4.12 Aprons

General

4.12.1 The design of aprons should take into consideration criteria for safe ground handling, including:

(a) sufficient space between aircraft stands to enable personnel and equipment to move safely and efficiently;

(b) adequate apron markings, apron signs and apron floodlighting;

(c) adequate staging and storage areas for ground support equipment (GSE);

(d) positioning of fixed ground services;

(e) storage areas for unit load devices (ULD);

(f) adequate access and egress routes for fuel, GSE and emergency vehicles;

(g) clearly delineated and visible access and egress routes for passengers;

(h) new technologies (electric charging points, autonomous vehicles, etc.);

(i) avoidance of rear of aircraft stand service roads wherever practicable; and

(j) appropriate protection for persons, equipment and infrastructure from jet blast and propeller wash.

Size of aprons

4.12.2 The total apron area should be adequate to permit safe and expeditious handling of the aerodrome traffic at its maximum anticipated density.

Slopes on aprons

4.12.3 Slopes on an apron, including those on an aircraft stand taxilane, should be sufficient to prevent accumulation of water on the surface of the apron but should be kept as level as drainage requirements permit.

4.13 Isolated aircraft parking position

4.13.1 The isolated aircraft parking position should be located at the maximum distance practicable and in any case never less than 100m from other parking positions, buildings or public areas, etc. Care should be taken to ensure that the position is

not located over underground utilities such as gas and aviation fuel and, to the extent feasible, electrical or communication cables.

5 GUIDANCE FOR CHAPTER 7 OF AS-5: OBSTACLE RESTRICTION AND REMOVAL

5.1 The specifications in Chapter 7 of AS-5 describes the management of obstacles within the aerodrome boundary and in its vicinity. The specifications allow the definition of airspace around aerodromes to be maintained free from obstacles and the airspace where flexibility can be applied in managing the obstacle environment. This permits the existing and intended aeroplane operations at the aerodromes to be conducted safely and prevent the aerodromes from becoming restricted and eventually unusable by the growth of obstacles. This is achieved by establishing obstacle limitation surfaces (OLS) consisting of obstacle free surfaces (OFS) and obstacle evaluation surfaces (OES).

5.2 The lateral and vertical extent of the OLS are being used in defining the requirements for the collection of terrain and obstacle data sets. Provisions on terrain and obstacle data sets are contained in Annex 15 Aeronautical Information Services, Chapter 5.

5.3 The establishment of, and requirements for, an obstacle protection surface for visual approach slope indicator systems are specified in AS-5 Chapter 8, 8.3.4.40 to 8.3.4.44.

Obstacle free surfaces (OFS)

Approach surface

5.4 The slope of the approach surface should not be increased to facilitate the growth of obstacles.

5.5 The slope of the approach surface is intended to adapt to approach operations that have a slope higher than 3.0°. Specifications concerning the modification of the approach surface are contained in PANS-Aerodromes (Doc 9981), Part II, Chapter 10.

Obstacle evaluation surfaces (OES)

5.6 The OES detailed in the following specifications address most common flight operations and operating minima. When the flight operations differ (e.g. variance in alignment, approach slope, approach minima) specific obstacle evaluation surfaces may need to be established. Depending on the flight operations and procedures available at an aerodrome, the OES may have specifications as specified in the following provisions or may be varied to fit the operations at the aerodrome (e.g. in case of increased minima or where circling does not occur on one side of the runway). There will be instances where additional obstacle evaluation surfaces, beyond what are specified in the section – Obstacle evaluation surfaces, may be required as the OES or its variations do not satisfactorily cover the local aeroplane operations specific to the aerodrome.

5.7 Detailed specifications on the variation of the OES and their design are contained in PANS-Aerodromes (Doc 9981).

General

5.8 The characteristics and dimensions of the obstacle evaluation surfaces should be in accordance with the provisions contained in AS-5 Paragraph 7.2.2 to 7.2.6.

5.9 Where it is necessary to preserve the accessibility of an aerodrome to existing and planned operations, the provisions applicable to OFS contained in Regulation 26 of ANR-139, AS-5 paragraph 7.3.4 to 7.3.5 and AC139-4-2 paragraph 5.25 should apply to the identified obstacle evaluation surface.

5.10 Detailed specifications are contained in PANS-Aerodromes (Doc 9981), Part II, Chapter 10.

Horizontal surface

5.11 A horizontal surface should have a radius of not less than, and a height of not greater than, those specified in Table 5-10.

Table 5-10. Dimensions of horizontal surface

Aeroplane design group	I-IIA	IIB	IIC	III	IV	V
Radius	3 350 m	5 350 m	10 750 m	10 750 m	10 750 m	10 750 m
Height	45 m	60 m	90 m	90 m	90 m	90 m

5.12 Where a runway is intended for the operations of aeroplanes of different aeroplane design groups, all the horizontal surfaces specified by the radii and heights associated with these groups are retained and the horizontal surface is composed of multiple surfaces located at different heights above the aerodrome elevation.

Surface for straight-in instrument approaches

5.13 The heights of the surface for straight-in instrument approaches should not be greater than, and its other dimensions not less than, those specified in Table 5-11.

Table 5-11. Dimensions of surface for straight-in instrument approaches

	Aeroplane design group	I to V
Lower section		45 m
	Height	
	Length	Horizontal OES as per ADG I
Upper section	**Height**	60 m
	Length of shorter side	7 410 m
	Length of longer side from the threshold or thresholds	5 350 m

Surface for precision approaches

5.14 The slope of the approach component should be measured in the vertical plane containing the centre line of the runway and its extension.

5.15 The slope of the missed approach component should be measured in the vertical plane containing the centre line of the runway and its extension.

5.16 The slope of the transitional component should be measured in the vertical plane perpendicular to the centre line of the runway and its extension.

5.17 The slopes of the different components of the surface for precision approach runways should not be greater than, and their other dimensions not less than, those specified in Table 5-12.

Table 5-12. Dimensions of surface for precision approaches

Aeroplane design group			I to V
Approach component		Distance from threshold	60 m
		Length of inner edge	300 m
	1st section	Length	3 000 m
		Divergence (each side)	15 %
		Slope	2 %
	2nd section	Length	9 600 m
		Divergence (each side)	15 %
		Slope	2.5 %
Missed approach component		Distance after threshold	900 m
		Length of inner edge	300 m
Aeroplane design group			**I to V**
	1st section	Length	1 800 m
		Divergence (each side)	17.48 %
		Slope	2.5 %
	2nd section	Length	10 200 m
		Divergence (each side)	25 %
		Slope	2.5 %
Transitional component		Slope	14.3 %

Instrument departure surface

5.18 The slope of the instrument departure surface should not be greater than, and its other dimensions not less than, those specified in Table 5-13.

Table 5-13. Dimensions of instrument departure surface

	Aeroplane design group	I to V
	Length of inner edge	300 m
	Slope	2.5 %
First section	Length	3 500 m
	Divergence	26.8 %
Second section	Length	8 300 m
	Divergence	57.8 %

Take-off climb surface

5.19 The take-off climb surface should vary when take-off flight paths involving turns are utilised; two sides originating at the end of the inner edge and diverging uniformly at a specified rate from the extended centre line of the take-off ground track to a specified final width, and extending thereafter parallel to the take-off ground track for the remainder of the length of the take-off climb surface.

5.20 On runways intended for operations of aeroplanes with a maximum certificated take-off mass up to 5 700 kg, the slope of the take-off climb surface should not be greater than, and its other dimensions not less than, those specified in Table 5-14, except that:

(a) a lesser length should be adopted for the take-off climb surface where such lesser length would be consistent with procedural measures adopted to govern the outward flight of aeroplanes; and

(b) a higher slope should be adopted for the take-off climb surface where such slope would be consistent with the operational characteristics of the critical aeroplane operating out of the runway and the local conditions.

5.21 On runways intended for operations of aeroplanes with a maximum certificated take-off mass greater than 5 700 kg, the slope of the take-off climb surface should not be greater than, and its other dimensions not less than, those specified in Table 5-15, except that:

(a) a lesser length should be adopted for the take-off climb surface where such lesser length would be consistent with procedural measures adopted to govern the outward flight of aeroplanes; and

(b) a higher slope should be adopted for the take-off climb surface where such slope would be consistent with the operational characteristics of the critical aeroplane operating out of the runway and the local conditions.

5.22 The slope of the take-off climb surface should not be increased to facilitate the growth of obstacles.

5.23 The slope of the take-off climb surface is intended to adapt to the operations of aeroplanes whose climb performances on take-off climb are such that a slope of 2 per cent is not necessary. However, this slope is not intended to be increased to enable the growth of obstacles. Specifications concerning the increase of the slope of the take-off climb surface are contained in PANS-Aerodromes (Doc 9981), Part II, Chapter 10.

5.24 The operational characteristics of aeroplanes for which the runway is intended should be examined to see if it is desirable to reduce the slope specified in Table 5-14 and Table 5-15 to 1.6 per cent when critical operating conditions are to be catered to. If the specified slope is reduced, corresponding adjustment in the length of the take-off climb surface should be made so as to provide protection to a height equal to that reached with the slopes and lengths in Table 5-14 and 5-15.

Table 5-14. Dimensions of take-off climb surface – runways with operations of aeroplanes with a mass up to 5 700 kg

Distance from runway end[b]	30 m	60 m	-	-	-	-
Length of inner edge	60 m	80 m	-	-	-	-
Divergence (each side)	10%	10%	-	-	-	-
Final width	380 m	580 m	-	-	-	-
Length	1 600 m	2 500 m	-	-	-	-
Slope	5%	4%	-	-	-	-
Aeroplane design group	**I**	**IIA-IIB**	**IIC**[a]	**III**[a]	**IV**[a]	**V**[a]

a. Aeroplanes with a mass up to but not including 5 700 kg generally belong to aeroplane design groups I, IIA and IIB.
b. The take-off climb surface starts at the end of the clearway if the clearway length exceeds the specified distance.

Table 5-15. Dimensions of take-off climb surface – runways with operations of aeroplanes with a mass above 5 700 kg

Aeroplane design group	**I**	**IIA-IIB**	**IIC**	**III**	**IV**	**V**
Distance from TODA	-	-	-	-	-	-
Length of inner edge	144 m	156 m	156 m	172 m	180 m	180 m
Divergence (each side)	12.5%	12.5%	12.5%	12.5%	12.5%	12.5%
Final width	1 800 m[a]	1 800 m[a]	1 800 m[a]	1 800 m[a]	1 800 m[a]	1 800 m[a]
Length	10 000 m	10 000 m	10 000 m	10 000 m	10 000 m	10 000 m
Slope	5%	4%	2%	2%	2%	2%

[a] Where given operational conditions and performances are met, the final width can be decreased. Specifications concerning this reduction are contained in the *Airport Services Manual* (Doc 9137), Part 6.

Obstacle limitation requirements

Obstacle free surfaces

5.25 Existing obstacles above the approach surface, and transitional surfaces or that complex surface extending between the lower edges of the transitional surfaces should as far as practicable be removed.

Obstacle limitation surfaces requirements

5.26 The requirements for obstacle free surfaces are specified on the basis of the intended use of a runway and are intended to be applied when such use is made of the runway.

5.27 The requirements for obstacle evaluation surfaces are specified on the basis of the intended use and/or intended operations on the runway. When different obstacle evaluation surfaces overlap each other, each individual surface must be considered as they have specific functions.

Objects outside the obstacle free surfaces and obstacle evaluation surfaces

5.28 In areas beyond the limits of the obstacle limitation surfaces, at least those objects which extend to a height of 100 m or more above ground elevation should be regarded as obstacles, unless an aeronautical study indicates that they do not constitute a hazard to the operations of intended aeroplane.

6 GUIDANCE FOR CHAPTER 8 OF AS-5: VISUAL AIDS FOR NAVIGATION

6.1 Indicators and signalling devices

6.1.1 Wind direction indicator

6.1.1.1 The wind direction indicator should be in the form of a truncated cone made of fabric and should have a length of not less than 3.6 m and a diameter, at the larger end, of not less than 0.9 m. It should be constructed so that it gives a clear indication of the direction of the surface wind and a general indication of the wind speed.

6.1.1.2 The colour or colours should be so selected as to make the wind direction indicator clearly visible and understandable from a height of at least 300 m, having regard to background. Where practicable, a single colour, preferably white or orange, should be used. Where a combination of two colours is required to give adequate contrast against changing backgrounds, they should preferably be orange and white, red and white, or black and white, and should be arranged in five alternate bands, the first and last bands being the darker colour.

6.1.1.3 The location of at least one wind direction indicator should be marked by a circular band 15 m in diameter and 1.2 m wide. The band should be centred about the wind direction indicator support and should be in a colour chosen to make the wind direction indictor conspicuous, preferably in white.

6.1.2 Landing direction indicator

6.1.2.1 The landing direction indicator should be in the form of a “T”.

6.1.3 Signalling lamp

6.1.3.1 A signalling lamp should be capable of producing red, green and white signals, and of:

(a) being aimed manually at any target as required;
(b) giving a signal in any one colour followed by a signal in either of the two other colours; and
(c) transmitting a message in any one of the three colours by Morse Code up to a speed of at least four words per minute.

When selecting the green light, use should be made of the restricted boundary of green as specified in paragraph 12.1.1.1.

6.1.3.2 The beam spread should be not less than 1° nor greater than 3°, with negligible light beyond 3°. When the signalling lamp is intended for use in the daytime the intensity of the coloured light should be not less than 6 000 cd.

6.1.4 Signal panels and signal area

6.1.4.1 The signal area should be located so as to be visible for all angles of azimuth above an angle of 10° above the horizontal when viewed from a height of 300 m.

6.1.4.2 The colour of the signal area should be chosen to contrast with the colours of the signal panels used, and it should be surrounded by a white border not less than 0.3 m wide.

6.2 Markings

6.2.1 General

Interruption of runway markings

6.2.1.1 The order of importance of runways for the display of runway markings should be as follows:

1st — precision approach runway;
2nd — non-precision approach runway; and
3rd — non-instrument runway.

Colour and conspicuity

6.2.1.2 At aerodromes where operations take place at night, pavement markings should be made with reflective materials designed to enhance the visibility of the markings.

6.2.1.3 Guidance on reflective materials is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 4.

Unpaved taxiways

6.2.1.4 An unpaved taxiway should be provided, so far as practicable, with the markings prescribed for paved taxiways.

6.2.2 Runway designation marking

6.2.2.1 A runway designation marking should be provided, so far as practicable, at the thresholds of an unpaved runway.

6.2.3 Threshold marking

Application

6.2.3.1 *[deleted]*

6.2.3.2 A threshold marking should be provided, so far as practicable, at the thresholds of an unpaved runway.

6.2.3.3 The ICAO Aerodrome Design Manual, Part 4, shows a form of marking which has been found satisfactory for the marking of downward slopes immediately before the threshold.

Transverse stripe

6.2.3.4 Where a threshold is displaced from the extremity of a runway or where the extremity of a runway is not square with the runway centre line, a transverse stripe as shown in AS-5 Figure 8-4 (B) should be added to the threshold marking.

6.2.4 Aiming point marking

6.2.4.1 An aiming point marking should be provided at each approach end of:

(a) a paved non-instrument runway where the code number is 3 or 4,
(b) a paved instrument runway where the code number is 1,

when additional conspicuity of the aiming point is desirable.

6.2.5 Touchdown zone marking

Application

6.2.5.1 A touchdown zone marking should be provided in the touchdown zone of a paved non-precision approach or non-instrument runway where the code number is 3 or 4 and additional conspicuity of the touchdown zone is desirable.

6.2.5.2 On a non-precision approach runway where the code number is 2, an additional pair of touchdown zone marking stripes should be provided 150m beyond the beginning of the aiming point marking.

6.2.6 Runway side stripe marking

Application

6.2.6.1 A runway side stripe marking should be provided on a precision approach runway irrespective of the contrast between the runway edges and the shoulders or the surrounding terrain.

Location

6.2.6.2 A runway side stripe marking should consist of two stripes, one placed along each edge of the runway with the outer edge of each stripe approximately on the edge of the runway, except that, where the runway is greater than 60m in width, the stripes should be located 30m from the runway centre line.

6.2.6.3 Where a runway turn pad is provided, the runway side stripe marking should be continued between the runway and the runway turn pad.

Characteristics

6.2.6.4 A runway side stripe should have an overall width of at least 0.9 m on runways 30m or more in width and at least 0.45m on narrower runways.

6.2.7 Taxiway centre line marking

Application

6.2.7.1 Taxiway centre line marking should be provided on a paved taxiway and apron where the code number is 1 or 2 in such a way as to provide continuous guidance between the runway centre line and aircraft stands.

6.2.7.2 Where it is necessary to denote the proximity of a runway-holding position, enhanced taxiway centre line marking should be provided.

6.2.7.3 The provision of enhanced taxiway centre line marking may form part of runway incursion prevention measures.

Location

6.2.7.4 On a straight section of a taxiway, the taxiway centre line marking should be located along the taxiway centre line. On a taxiway curve, the marking should continue from the straight portion of the taxiway at a constant distance from the outside edge of the curve. See paragraph 4.9.2 and Figure 4-1.

6.2.7.5 At an intersection of a taxiway with a runway where the taxiway serves as an exit from the runway, the taxiway centre line marking should be curved into the runway centre line marking as shown in AS-5 Figures 8-6 and 8-22. The taxiway centre line marking should be extended parallel to the runway centre line marking for a distance of at least 60 m beyond the point of tangency where the code number is 3 or 4, and for a distance of at least 30 m where the code number is 1 or 2.

6.2.7.6 Where taxiway centre line marking is provided on a runway in accordance with AS-5 paragraph 8.2.8.2, the marking should be located on the centre line of the designated taxiway.

6.2.8 Runway turn pad marking

Location

6.2.8.1 The runway turn pad markings should be curved from the runway centre line into the turn pad. The radius of the curve should be compatible with the manoeuvring capability and normal taxiing speeds of the aeroplanes for which the runway turn pad is intended. The intersection angle of the runway turn pad marking with the runway centre line should not be greater than 30 degrees.

6.2.8.2 The runway turn pad markings should be extended parallel to the runway centre line marking or a distance of at least 60 m beyond the point of tangency where the code number is 3 or 4, and for a distance of at least 30 m where the code number is 1 or 2.

6.2.8.3 The runway turn pad marking should guide the aeroplane in such a way as to allow a straight portion of taxiing before the point where a 180-degree turn is to be made.

The straight portion of the runway turn pad marking should be parallel to the outer edge of the runway turn pad.

6.2.8.4 The design of the curve allowing the aeroplane to negotiate a 180-degree turn should be based on a nose wheel steering angle not exceeding 45 degrees.

6.2.8.5 The design of the turn pad marking should be such that, when the cockpit of the aeroplane remains over the runway turn pad marking, the clearance distance between any wheel of the aeroplane landing gear and the edge of the runway turn pad should be not less than those specified in AS-5 paragraph 6.3.2.

6.2.8.6 For ease of manoeuvring, consideration may be given to providing a larger wheel-to-edge clearance for codes E and F aeroplanes.

6.2.9 Runway-holding position marking

6.2.9.1 Where increased conspicuity of the runway-holding position is required, the dimensions of runway-holding position marking should be as shown in AS-5 Figure 8-8, pattern A2 or pattern B2, as appropriate.

6.2.9.2 An increased conspicuity of the runway-holding position can be required, notably to avoid incursion risks.

6.2.9.3 Where a pattern B runway-holding position marking is located on an area where it would exceed 60m in length, the term “CAT II” or “CAT III” as appropriate should be marked on the surface at the ends of the runway-holding position marking and at equal intervals of 45m maximum between successive marks. The letters should be not less than 1.8m high and should be placed not more than 0.9m beyond the holding position marking.

6.2.10 Intermediate holding position marking

Application and location

6.2.10.1 An intermediate holding position marking should be displayed along an intermediate holding position.

6.2.11 VOR aerodrome check-point marking

Characteristics

6.2.11.1 When it is preferable for an aircraft to be aligned in a specific direction, a line should be provided that passes through the centre of the circle on the desired azimuth. The line should extend 6m outside the circle in the desired direction of heading and terminate in an arrowhead. The width of the line should be 15cm (see AS-5 Figure 8-9 (B)).

6.2.11.2 A VOR aerodrome check-point marking should preferably be white in colour but should differ from the colour used for the taxiway markings.

6.2.11.3 To provide contrast, markings may be bordered with black.

6.2.12 Aircraft stand markings

6.2.12.1 Guidance on the layout of aircraft stand markings is contained in the ICAO Aerodrome Design Manual (Doc 9157), Part 4.

Application

6.2.12.2 Aircraft stand markings should be provided for designated parking positions on a paved apron.

Location

6.2.12.3 Aircraft stand markings on a paved apron should be located so as to provide the clearances specified in AS-5 paragraph 6.13.4, when the nose wheel follows the stand marking.

Characteristics

6.2.12.4 Aircraft stand markings should include such elements as stand identification, lead-in line, turn bar, turning line, alignment bar, stop line and lead-out line, as are required by the parking configuration and to complement other parking aids.

6.2.12.5 An aircraft stand identification (letter and/or number) should be included in the lead-in line a short distance after the beginning of the lead-in line. The height of the identification should be adequate to be readable from the cockpit of aircraft using the stand.

6.2.12.6 Where two sets of aircraft stand markings are superimposed on each other in order to permit more flexible use of the apron and it is difficult to identify which stand marking should be followed, or safety would be impaired if the wrong marking was followed, then identification of the aircraft for which each set of markings is intended should be added to the stand identification (Example: 2A-B747, 2B-F28).

6.2.12.7 Lead-in, turning and lead-out lines should normally be continuous in length and have a width of not less than 15cm. Where one or more sets of stand markings are superimposed on a stand marking, the lines should be continuous for the most demanding aircraft and broken for other aircraft.

6.2.12.8 The curved portions of lead-in, turning and lead-out lines should have radii appropriate to the most demanding aircraft type for which the markings are intended.

6.2.12.9 Where it is intended that an aircraft proceed in one direction only, arrows pointing in the direction to be followed should be added as part of the lead-in and lead-out lines.

6.2.12.10 A turn bar should be located at right angles to the lead-in line, abeam the left pilot position at the point of initiation of any intended turn. It should have a length and width of not less than 6m and 15cm, respectively, and include an arrowhead to indicate the direction of turn.

6.2.12.11 The distances to be maintained between the turn bar and the lead-in line may vary according to different aircraft types, taking into account the pilot’s field of view.

6.2.12.12 If more than one turn bar and/or stop line is required, they should be coded.

6.2.12.13 An alignment bar should be placed so as to be coincident with the extended centre line of the aircraft in the specified parking position and visible to the pilot during the final part of the parking manoeuvre. It should have a width of not less than 15cm.

6.2.12.14 A stop line should be located at right angles to the alignment bar, abeam the left pilot position at the intended point of stop. It should have a length and width of not less than 6m and 15cm, respectively.

6.2.12.15 The distances to be maintained between the stop line and the lead-in line may vary according to different aircraft types, taking into account the pilot's field of view.

6.2.13 Apron safety lines

Application

6.2.13.1 Apron safety lines should be provided on a paved apron as required by the parking configurations and ground facilities.

Characteristics

6.2.13.2 Apron safety lines should include such elements as wing tip clearance lines and service road boundary lines as required by the parking configurations and ground facilities.

6.2.13.3 An apron safety line should be continuous in length and at least 10cm in width.

6.2.14 Mandatory instruction marking

6.2.14.1 Where operationally required, such as on taxiways exceeding 60m in width, or to assist in the prevention of a runway incursion, a mandatory instruction sign should be supplemented by a mandatory instruction marking.

6.2.14.2 Except where operationally required, a mandatory instruction marking should not be located on a runway.

6.2.14.3 The character height should be 4m for inscriptions where the OMGWS is from 6m up to but not including 15m, and 2m where the OMGWS is up to but not including 6m. The inscriptions should be in the form and proportions shown in AS-5 Appendix 4.

6.2.14.4 The background should be rectangular and extend a minimum of 0.5m laterally and vertically beyond the extremities of the inscription.

6.2.15 Information marking

6.2.15.1 Where operationally required, an information sign should be supplemented by an information marking.

6.2.15.2 An information (location/direction) marking should be displayed prior to and following complex taxiway intersections and where operational experience has

indicated the addition of a taxiway location marking could assist flight crew ground navigation.

6.2.15.3 An information (location) marking should be displayed on the pavement surface at regular intervals along taxiways of great length.

Location

6.2.15.4 The information marking should be displayed across the surface of the taxiway or apron where necessary and positioned so as to be legible from the cockpit of an approaching aircraft.

6.2.15.5 The character height should be 4m. The inscriptions should be in the form and proportions shown in AS-5 Appendix 4.

6.3 Lights

6.3.1 General

Laser emissions which may endanger the safety of aircraft

6.3.1.1 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); and
(c) a laser-beam sensitive flight zone (LSFZ).

6.3.1.2 Figures 6-1, 6-2 and 6-3 may be used to determine the exposure levels and distances that adequately protect flights operations.

6.3.1.3 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 air space, the irradiance level of any laser beam, visible or invisible, is expected to be less than or equal to the maximum permissible exposure (MPE).

6.3.1.4 The protected flight zones are established in order to mitigate the risks of operating laser emitters in the vicinity of aerodromes.

6.3.1.5 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 Flights Safety (Doc 9815).

6.3.1.6 See also ICAO Annex 11 – Air Traffic Services, Chapter 2.

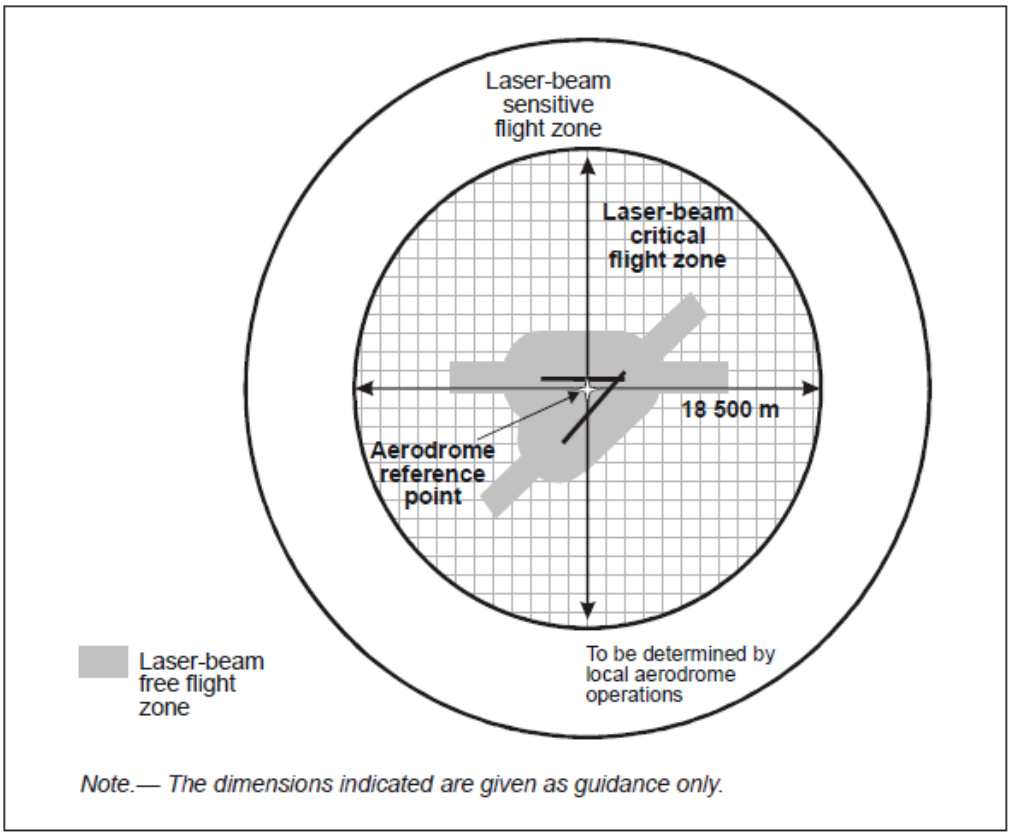

Figure 6-1. Protected flight zones

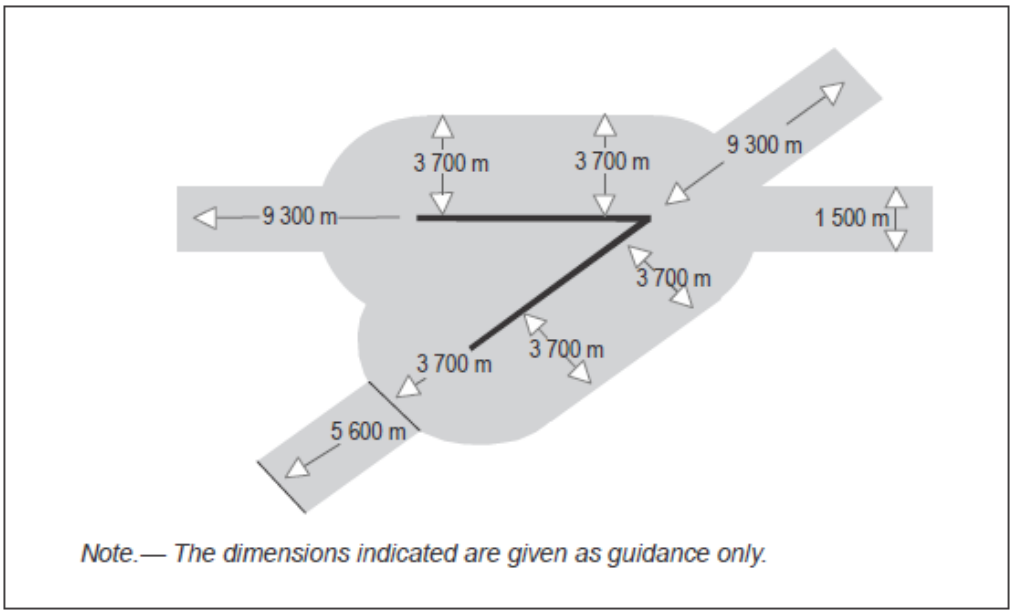

Figure 6-2. Multiple runway laser-beam free flight zone

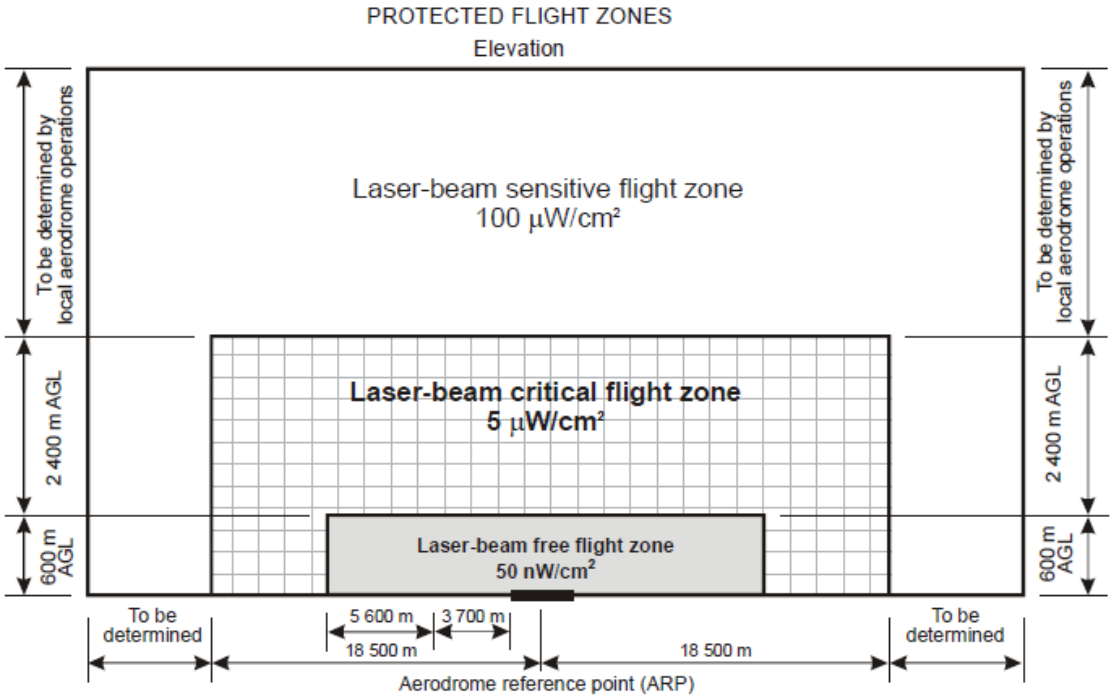

Figure 6-3. Protected flight zones with indication of maximum irradiance levels for visible laser beams

Lights which may cause confusion

6.3.1.7 Unless otherwise permitted by CAAS under para 72 of the ANO, a non-aeronautical ground light which, by reason of its intensity, configuration or colour, might prevent, or cause confusion in, the clear interpretation of aeronautical ground lights, must 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 500m in length from the threshold and runway end and 750m 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

6.3.1.8 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.

Light fixtures and supporting structures

6.3.1.9 See AS-5 paragraph 12.5 for information regarding siting of equipment and installations on operational areas, and the ICAO Aerodrome Design Manual (Doc 9157), Part 6 for guidance on frangibility of light fixtures and supporting structures.

Surface lights

6.3.1.10 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.

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

6.3.2 Emergency lighting

Application

6.3.2.1 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.

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

Location

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

Characteristics

6.3.2.4 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.

6.3.3 Aeronautical beacons

Aerodrome beacon

6.3.3.1 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.

Identification beacon

6.3.3.2 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.

6.3.3.3 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.

6.3.4 Approach lighting systems

Application

6.3.4.1 A — Non-instrument runway

Where physically practicable, a simple approach lighting system as specified in AS-5 paragraphs 8.3.3.2 to 8.3.3.6 and paragraphs 6.3.4.3 to 6.3.4.5 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.

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

Simple approach lighting system

Location

6.3.4.3 If it is not physically possible to provide a centre line extending for a distance of 420m from the threshold, it should be extended to 300m 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 3m in length. Subject to the approach system having a crossbar at 300m from the threshold, an additional crossbar may be provided at 150m from the threshold.

Characteristics

6.3.4.4 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.

6.3.4.5 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

Characteristics

6.3.4.6 If the centre line consists of barrettes as described in AS-5 paragraphs 8.3.3.11 (b) or 8.3.3.12 (b), each barrette should be supplemented by a flashing light, except where such lighting is considered unnecessary taking into account the characteristics of the system and the nature of the meteorological conditions.

Precision approach category II and III lighting system

Characteristics

6.3.4.7 If the centre line beyond 300m from the threshold consists of barrettes as described in AS-5 paragraphs 8.3.3.27 (a) or 8.3.3.28 (a), each barrette beyond 300m should be supplemented by a flashing light, except where such lighting is considered unnecessary taking into account the characteristics of the system and the nature of the meteorological conditions.

6.3.5 Visual approach slope indicator systems

Application

6.3.5.1 The use of T-VASIS and AT-VASIS as standard visual approach slope indicator systems should be discontinued.

6.3.5.2 Where a runway threshold is temporarily displaced from the normal position and one or more of the conditions specified in AS-5 paragraph 8.3.4.1 exist, a PAPI should be provided except that where the code number is 1 or 2 an APAPI may be provided.

6.3.6 Circling guidance lights

Application

6.3.6.1 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

6.3.6.2 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.

6.3.6.3 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.

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

Characteristics

6.3.6.5 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.

6.3.6.6 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.

6.3.7 Runway lead-in lighting systems

Application

6.3.7.1 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.

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

Location

6.3.7.3 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.

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

6.3.7.5 A runway lead-in lighting system should extend from a point based on an aeronautical study, up to a point where the approach lighting system, if provided, or the runway or the runway lighting system is in view.

Characteristics

6.3.7.6 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.

6.3.7.7 The flashing lights and the steady burning lights should be white.

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

6.3.8 Runway threshold identification lights

Application

6.3.8.1 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.

Characteristics

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

6.3.9 Runway edge lights

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

6.3.9.2 Where the width of the area which could be declared as runway exceeds 60m, 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.

6.3.10 Runway threshold and wing bar lights

Location of runway threshold lights

6.3.10.1 The lights prescribed in AS-5 paragraphs 8.3.7.4 (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

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

6.3.11 Runway end lights

6.3.11.1 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.

6.3.12 Runway centre line lights

6.3.12.1 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.

6.3.12.2 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.

6.3.12.3 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 length and spaced at uniform intervals of 30 m, as shown in Figure 6-4, 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.

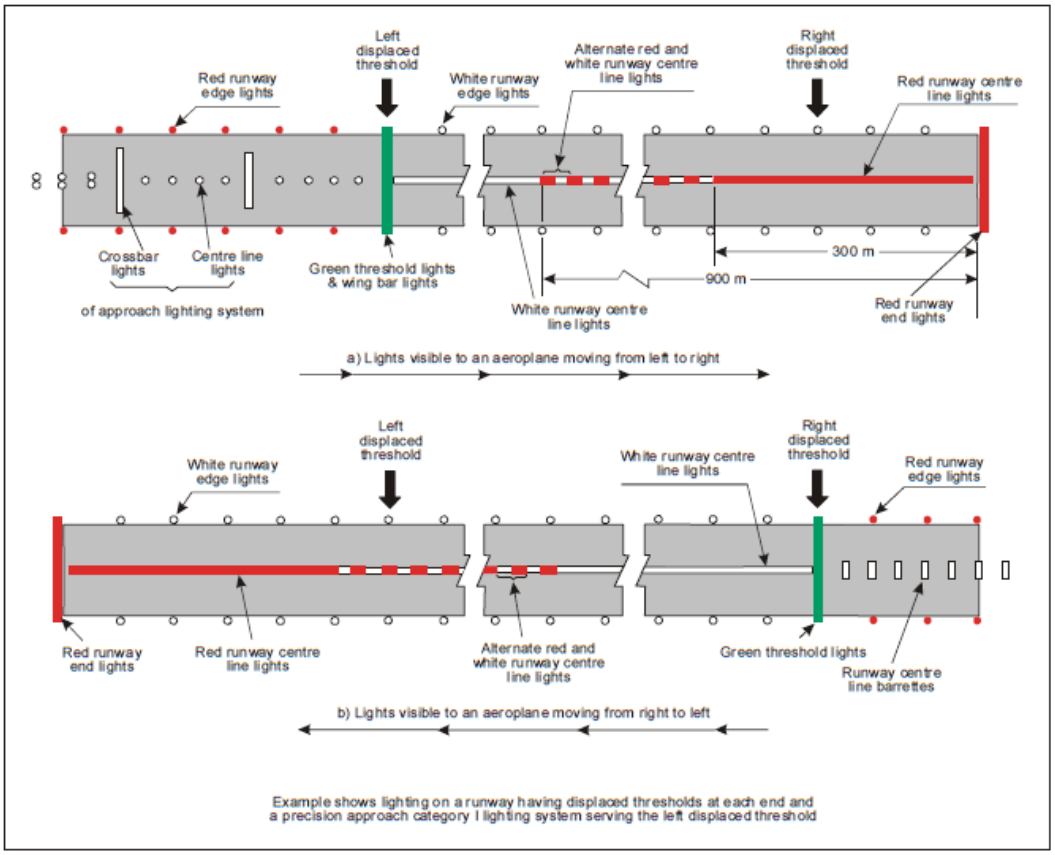

Figure 6-4. Example of approach and runway lighting for runway with displaced thresholds

6.3.13 Runway touchdown zone lights

Characteristics

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

6.3.14 Simple touchdown zone lights

6.3.14.1 The purpose of simple touchdown zone (TDZ) 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.

6.3.14.2 Except where TDZ lights are provided in accordance with AS-5 paragraph 8.3.10, 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.

6.3.14.3 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.

6.3.15 Rapid exit taxiway indicator lights

Application

6.3.15.1 Rapid exit taxiway indicator lights should be provided on a runway intended for use in runway visual range conditions less than a value of 300m and/or where the traffic density is heavy. See ICAO Annex 14, Vol. I, Attachment A, Section 14

Characteristics

6.3.15.2 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.

6.3.16 Taxiway centre line lights

6.3.16.1 Taxiway centre line lights should be provided on a taxiway intended for use at night in runway visual range conditions of 300m 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.

6.3.16.2 Where there may be a need to delineate the edges of a taxiway, e.g. on a rapid exit taxiway or narrow taxiway, this may be done with taxiway edge lights or markers.

6.3.16.3 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.

6.3.16.4 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.

6.3.16.5 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.

6.3.16.6 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.

6.3.16.7 The provisions of paragraph 6.3.16.5 can form part of effective runway incursion prevention measures

6.3.16.8 Where higher intensities are required, from an operational point of view, taxiway centre line lights on rapid taxiways intended for use in runway visual range conditions less than a value of 300m should be in accordance with the specifications of AS-5 Appendix 3, Figure A3-12. The number of levels of brilliancy settings for these lights should be the same as that for the runway centre line lights.

6.3.16.9 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 AS-5 Appendix 3, Figure A3-17, A3-18 or A3-19.

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

Location

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

Taxiway centre line lights on taxiways

Location

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

(a) larger intervals not exceeding 60m may be used where, because of the prevailing meteorological conditions, adequate guidance is provided by such spacing;
(b) intervals less than 30m should be provided on short straight sections; and

(c) on a taxiway intended for use in RVR conditions of less than a value of 300m, the longitudinal spacing should not exceed 15m.

6.3.16.13 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 spaced at intervals such that a clear indication of the curve is provided.

6.3.16.14 On a taxiway intended for use in RVR conditions of less than a value of 300m, the lights on a curve should not exceed a spacing of 15m and on a curve of less than 400m radius the lights should be spaced at intervals of not greater than 7.5m. This spacing should extend for 60m before and after the curve.

6.3.16.15 Spacings on curves that have been found suitable for a taxiway intended for use in RVR conditions of 300m or greater are:

Curve radius	Light spacing
up to 400 m	7.5m
401 m to 899 m	15m
900 m or greater	30m

See paragraph 4.9.2 and Figure 4-1.

Taxiway centre line lights on rapid exit taxiways

Location

6.3.16.16 Taxiway centre line lights on a rapid exit taxiway should commence at a point at least 60m 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 6-5.

6.3.16.17 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

6.3.16.18 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 60cm from any row of runway centre line lights, as shown in Figure 6-5.

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

Taxiway centre line lights on runways

Location

6.3.16.20 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 300m should be spaced at longitudinal intervals not exceeding 15m.

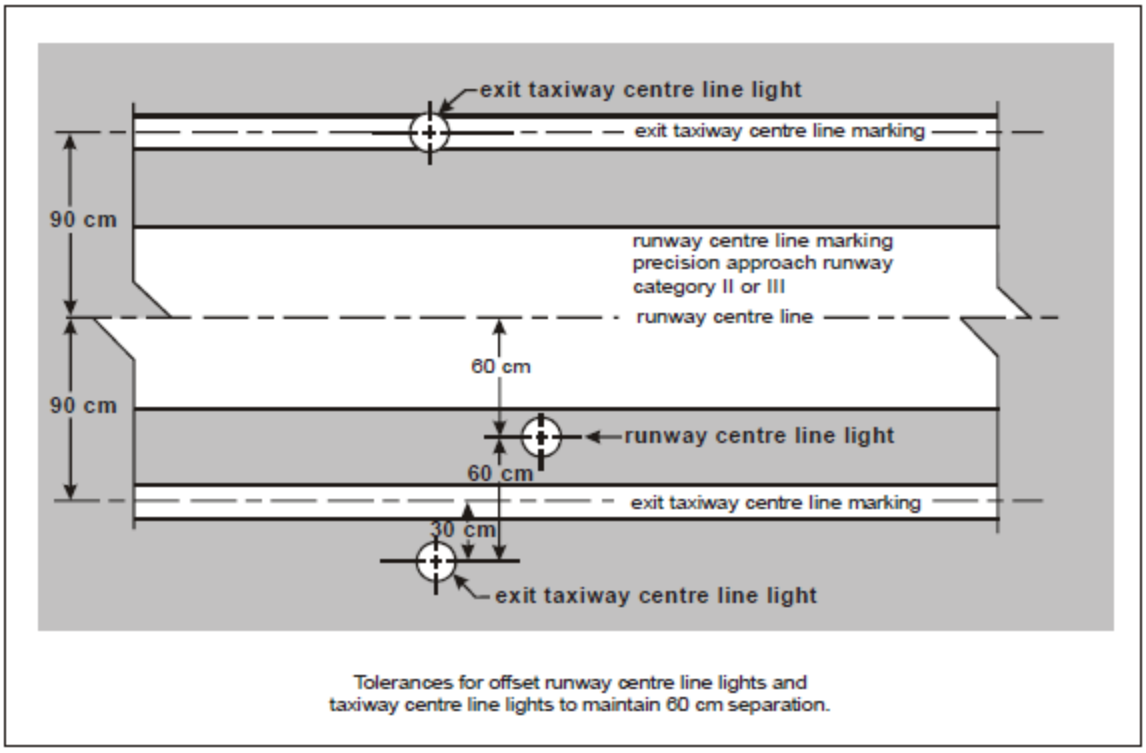

Figure 6-5. Offset runway and taxiway centre line lights

6.3.17 Taxiway edge lights

Location

6.3.17.1 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 60m. The lights on a curve should be spaced at intervals less than 60m so that a clear indication of the curve is provided.

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

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

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

6.3.17.5 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 3m.

6.3.18 Runway turn pad lights

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

Location

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

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

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

6.3.19 Stop bars

6.3.19.1 A stop bar is intended to be controlled either manually or automatically by the air traffic services.

6.3.19.2 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 in visibility conditions greater than 550m runway visual range can form part of effective runway incursion prevention measures.

Application

6.3.19.3 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

6.3.19.4 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 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.

6.3.19.5 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 AS-5 Appendix 3, Figure A3-17, A3-18 or A3-19.

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

6.3.19.7 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 AS-5 Appendix 3, Figure A3-17 or A3-19.

6.3.20 Intermediate holding position lights

Application

6.3.20.1 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.

6.3.21 Runway guard lights

6.3.21.1 Runway incursions may take place in all visibility or weather conditions. The use of runway guard lights at runway-holding positions can form part of effective runway incursion prevention measures. Runway guard lights warn pilots, and drivers of vehicles, when operating on taxiways that they are about to enter a runway. There are two standard configurations of runway guard lights as illustrated in AS-5 Figure 8-23.

Application

6.3.21.2 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.

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

Characteristics

6.3.21.4 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.

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

6.3.21.6 The intensity in yellow light and beam spreads of lights of Configuration A should be in accordance with the specifications in AS-5 Appendix 3, Figure A3-24.

6.3.21.7 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 AS-5 Appendix 3, Figure A3-25.

6.3.21.8 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 AS-5 Appendix 3, Figure A3-25.

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

6.3.21.10 The intensity in yellow light and beam spreads of lights of Configuration B should be in accordance with the specifications in AS-5 Appendix 3, Figure A3-12.

6.3.21.11 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 AS-5 Appendix 3, Figure A3-20.

6.3.21.12 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 B should be in accordance with the specifications in AS-5 Appendix 3, Figure A3-20.

6.3.22 Apron floodlighting

Application

6.3.22.1 Apron floodlighting should be provided on an apron and on a designated isolated aircraft parking position intended to be used at night.

6.3.22.2 The designation of an isolated aircraft parking position is specified in AS-5 paragraph 6.14 and paragraph 4.13.

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

Location

6.3.22.4 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

6.3.22.5 The average illuminance should be at least the following:
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 2m above the apron in relevant directions.

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.

6.3.23 Visual docking guidance system

Characteristics

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

Azimuth guidance unit

<u>Location</u>

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

Stopping position indicator

Location

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

Characteristics

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

6.3.24 Advanced visual docking guidance system

6.3.24.1 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 ICAO Document 8643), distance-to-go information and closing speed. Docking guidance information is usually provided on a single display unit.

6.3.24.2 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.

Application

6.3.24.3 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.

Characteristics

6.3.24.4 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 Table 6-1.

Table 6-1 – A-VDGS Recommended displacement accuracy

Guidance information	**max. deviation at stop position (stop area)**	**max. deviation at 9 m from stop position**	**max. deviation at 15 m from stop position**	**max. deviation at 25 m from stop position**
Azimuth	±250 mm	±340 mm	±400 mm	±500 mm
Distance	±500 mm	±1000 mm	±1300 mm	Not specified

6.3.24.5 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 3m prior to the stop position.

6.3.24.6 The word “STOP” in red characters should be displayed when an immediate cessation of the docking manoeuvre is required.

6.3.25 Aircraft stand manoeuvring guidance lights

Application

6.3.25.1 Aircraft stand manoeuvring guidance lights should be provided to facilitate the positioning of an aircraft on an aircraft stand on a paved apron intended for use in poor visibility conditions, unless adequate guidance is provided by other means.

Characteristics

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

6.3.25.3 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.

6.3.25.4 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.

6.3.26 Road-holding position light

Application

6.3.26.1 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 300m and 550m.

6.3.27 No-entry bar

6.3.27.1 Runway incursions may take place in all visibility or weather conditions. The use of no-entry bars can form part of effective runway incursion prevention measures.

Application

6.3.27.2 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

6.3.27.3 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.

6.3.27.4 A no-entry bar should be co-located with a no-entry sign and/or a no-entry marking.

Characteristics

6.3.27.5 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.

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

6.3.27.7 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.

6.3.27.8 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 AS-5 Appendix 3, Figure A3-17, A3-18 or A3-19.

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

6.3.27.10 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 AS-5 Appendix 3, Figure A3-17 or A3-19.

6.3.28 Runway status lights

6.3.28.1 Runway status lights (RWSL) is a type of autonomous runway incursion warning system (ARIWS). The two basic visual components of RWSL are runway entrance lights (RELs) and take-off hold lights (THLs). Either component may be installed by itself, but the two components are designed to be complementary to each other.

Characteristics

6.3.28.2 RELs and THLs should be automated to the extent that the only control over each system will be to disable one or both systems.

6.4 Signs

6.4.1 General

Application

6.4.1.1 A variable message sign should be provided where:

(a) the instruction or information displayed on the sign is relevant only during a certain period of time; and/or
(b) there is a need for variable pre-determined information to be displayed on the sign to meet the requirements of the surface movement guidance and control systems.

6.4.1.2 The time interval to change from one message to another on a variable message sign should be as short as practicable and should not exceed 5 seconds.

6.4.2 Mandatory instruction signs

Application

6.4.2.1 A runway designation sign at a taxiway/runway intersection should be supplemented with a location sign in the outboard (farthest from the taxiway) position, as appropriate.

6.4.2.2 See AS-5 paragraph 8.4.3 for characteristics of location signs.

Characteristics

6.4.2.3 Where, owing to environmental or other factors, the conspicuity of the inscription on a mandatory instruction sign needs to be enhanced, the outside edge of the white inscription should be supplemented by a black outline measuring 10 mm in width for runway code numbers 1 and 2, and 20 mm in width for runway code numbers 3 and 4.

6.4.3 Information signs

6.4.3.1 An intersection take-off sign should be provided when there is an operational need to indicate the remaining take-off run available (TORA) for intersection take-offs.

6.4.3.2 Where necessary, a destination sign should be provided to indicate the direction to a specific destination on the aerodrome, such as cargo area, general aviation, etc.

6.4.3.3 A location sign should be provided at an intermediate holding position.

6.4.3.4 Where necessary, a location sign should be provided to identify taxiways exiting an apron or taxiways beyond an intersection.

6.4.3.5 Where a taxiway ends at an intersection such as a ‘‘T’’ and it is necessary to identify this, a barricade, direction sign and/or other appropriate visual aid should be used.

Location

6.4.3.6 A destination sign should not normally be collocated with a location or direction sign.

6.4.3.7 A direction sign, barricade and/or other appropriate visual aid used to identify a ‘‘T’’ intersection should be located on the opposite side of the intersection facing the taxiway.

Characteristics

6.4.3.8 Where it is necessary to identify each of a series of intermediate holding positions on the same taxiway, the location sign should consist of the taxiway designation and a number.

6.4.3.9 When designating taxiways, the use of words such as inner and outer should be avoided wherever possible.

6.4.3.10 Apron stand designators should not be the same as taxiway designators.

6.4.4 VOR aerodrome check-point sign

6.4.4.1 The inscriptions on a VOR check-point sign should be in accordance with one of the alternatives shown in Figure 6-6 in which:

VOR	is an abbreviation identifying this as a VOR check-point;
116.3	is an example of the radio frequency of the VOR concerned;
147°	is an example of the VOR bearing[1], to the nearest degree, which should be indicated at the VOR check-point; and
4.3 NM	is an example of the distance in nautical miles to a DME collocated with the VOR concerned.

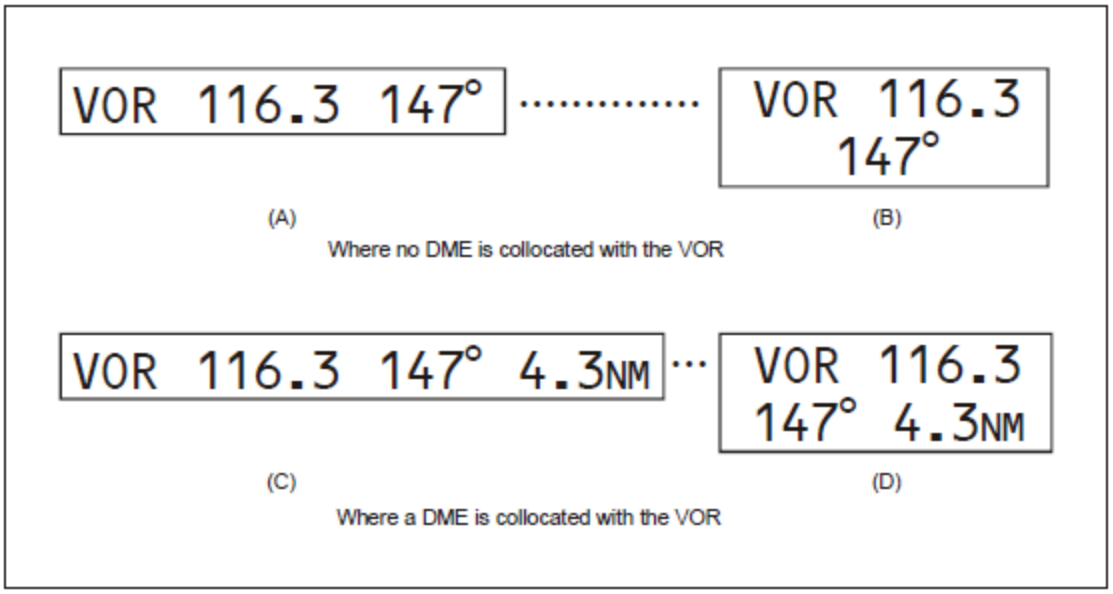

Figure 6-6. VOR aerodrome checkpoint sign

6.4.5 Aerodrome identification sign

Application

6.4.5.1 An aerodrome identification sign should be provided at an aerodrome where there is insufficient alternative means of visual identification.

Location

[1] Tolerances for the bearing value shown on the sign are given in ICAO Annex 10, Volume I, Attachment E. It will be noted that a check-point can only be used operationally when periodic checks show it to be consistently within ± 2 degrees of the stated bearing.

6.4.5.2 The aerodrome identification sign should be placed on the aerodrome so as to be legible, in so far as is practicable, at all angles above the horizontal.

6.4.5.3 The colour selected for the sign should give adequate conspicuity when viewed against its background.

6.4.5.4 The characters should have a height of not less than 3 m.

6.4.6 Aircraft stand identification signs

Application

6.4.6.1 An aircraft stand identification marking should be supplemented with an aircraft stand identification sign where feasible.

Location

6.4.6.2 An aircraft stand identification sign should be located so as to be clearly visible from the cockpit of an aircraft prior to entering the aircraft stand.

Characteristics

6.4.6.3 An aircraft stand identification sign should consist of an inscription in black on a yellow background.

6.5 Markers

6.5.1 Unpaved runway edge markers

Application

6.5.1.1 Markers should be provided when the extent of an unpaved runway is not clearly indicated by the appearance of its surface compared with that of the surrounding ground.

Location

6.5.1.2 Where runway lights are provided, the markers should be incorporated in the light fixtures. Where there are no lights, markers of flat rectangular or conical shape should be placed so as to delimit the runway clearly.

Characteristics

6.5.1.3 The flat rectangular markers should have a minimum size of 1 m by 3 m and should be placed with their long dimension parallel to the runway centre line. The conical markers should have a height not exceeding 50 cm.

6.5.2 Stopway edge markers

Application

6.5.2.1 Stopway edge markers should be provided when the extent of a stopway is not clearly indicated by its appearance compared with that of the surrounding ground.

6.5.3 Taxiway edge markers

Application

6.5.3.1 Taxiway edge markers should be provided on a taxiway where the code number is 1 or 2 and taxiway centre line or edge lights or taxiway centre line markers are not provided.

Location

6.5.3.2 Taxiway edge markers should be installed at least at the same locations as would the taxiway edge lights had they been used.

6.5.3.3 The marked surface as viewed by the pilot should be a rectangle and should have a minimum viewing area of 150 cm^2.

6.5.4 Taxiway centre line markers

Application

6.5.4.1 Taxiway centre line markers should be provided on a taxiway where the code number is 1 or 2 and taxiway centre line or edge lights or taxiway edge markers are not provided.

6.5.4.2 Taxiway centre line markers should be provided on a taxiway where the code number is 3 or 4 and taxiway centre line lights are not provided if there is a need to improve the guidance provided by the taxiway centre line marking.

Location

6.5.4.3 Taxiway centre line markers should be installed at least at the same location as would taxiway centre line lights had they been used.

6.5.4.4 See paragraph 6.3.16.11 for the spacing of taxiway centre line lights.

6.5.4.5 Taxiway centre line markers 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.

Characteristics

6.5.4.6 The marked surface as viewed by the pilot should be a rectangle and should have a minimum viewing area of 20cm^2.

6.5.5 Unpaved taxiway edge markers

Application

6.5.5.1 Where the extent of an unpaved taxiway is not clearly indicated by its appearance compared with that of the surrounding ground, markers should be provided.

Location

6.5.5.2 Where taxiway lights are provided, the markers should be incorporated in the light fixtures. Where there are no lights, markers of conical shape should be placed so as to delimit the taxiway clearly.

6.5.6 Boundary markers

Characteristics

6.5.6.1 Boundary markers should be of a form similar to that shown in AS-5 Figure 8-27, or in the form of a cone not less than 50cm high and not less than 75cm in diameter at the base. The markers should be coloured to contrast with the background against which they will be seen. A single colour, orange or red, or two contrasting colours, orange and white or alternatively red and white, should be used, except where such colours merge with the background.

7 GUIDANCE FOR CHAPTER 9 OF AS-5: VISUAL AIDS FOR DENOTING OBSTACLES

7.1 Objects to be marked and/or lighted

7.1.1 The marking and/or lighting of obstacles is intended to reduce hazards to aircraft by indicating the presence of the obstacles. It does not necessarily reduce operating limitations which may be imposed by an obstacle.

7.1.2 An autonomous aircraft detection system may be installed on or near an obstacle (or group of obstacles such as wind farms), designed to operate the lighting only when the system detects an aircraft approaching the obstacle, in order to reduce light exposure to local residents. Guidance on the design and installation of an autonomous aircraft detection system is available in the Aerodrome Design Manual (Doc 9157), Part 4. The availability of such guidance is not intended to imply that such a system has to be provided.

7.1.3 Objects within the lateral boundaries of the obstacle limitation surfaces

7.1.3.1 A fixed object, other than an obstacle, adjacent to a take-off climb surface should be marked and, if the runway is used at night, lighted, if such marking and lighting is considered necessary to ensure its avoidance, except that the marking may be omitted when:

(a) the object is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150m; or
(b) the object is lighted by high-intensity obstacle lights by day.

7.1.3.2 A fixed obstacle that extends above a horizontal surface should be marked and, if the aerodrome is used at night, lighted, except that:

(a) such marking and lighting may be omitted when:
    (i) the obstacle is shielded by another fixed obstacle; or

(ii) for a circuit extensively obstructed by immovable objects or terrain, procedures have been established to ensure safe vertical clearance below prescribed flight paths; or

(iii) an aeronautical study shows the obstacle not to be of significance to operational safety;

(b) the marking may be omitted when the obstacle is lighted by medium-intensity obstacle lights, Type A, by day and its height above the level of the surrounding ground does not exceed 150 m;

(c) the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day; and

(d) the lighting may be omitted where the obstacle is a lighthouse, and an aeronautical study indicates the lighthouse light to be sufficient.

7.1.3.3 Other objects inside the obstacle limitation surfaces should be marked and/or lighted if an aeronautical study indicates that the object could constitute a hazard to aircraft (this includes objects adjacent to visual routes e.g. waterway or highway). See paragraph 5.5.3.

7.1.3.4 Overhead wires, cables, etc., crossing a river, waterway, valley or highway should be marked and their supporting towers marked and lighted if an aeronautical study indicates that the wires or cables could constitute a hazard to aircraft.

7.1.4 Objects outside the lateral boundaries of the obstacle limitation surfaces

7.1.4.1 Obstacles in accordance with paragraph 5.4.2 should be marked and lighted, except that the marking may be omitted when the obstacle is lighted by high-intensity obstacle lights by day.

7.1.4.2 Other objects outside the obstacle limitation surfaces should be marked and/or lighted if an aeronautical study indicates that the object could constitute a hazard to aircraft (this includes objects adjacent to visual routes e.g. waterway, highway).

7.1.4.3 Overhead wires, cables, etc., crossing a river, waterway, valley or highway should be marked and their supporting towers marked and lighted if an aeronautical study indicates that the wires or cables could constitute a hazard to aircraft.

7.2 Marking and/or lighting of objects

7.2.1 Mobile objects

7.2.1.1 When mobile objects are marked by colour, a single conspicuous colour, preferably red or yellowish green for emergency vehicles and yellow for service vehicles, should be used.

7.2.2 Fixed objects

Marking by colour

7.2.2.1 An object should be coloured to show a chequered pattern if it has essentially unbroken surfaces and its projection on any vertical plane equals or exceeds 4.5m

in both dimensions. The pattern should consist of rectangles of not less than 1.5m and not more than 3m on a side, the corners being of the darker colour. The colours of the pattern should contrast each with the other and with the background against which they will be seen. Orange and white or alternatively red and white should be used, except where such colours merge with the background. (See Figure 7-1.)

7.2.2.2 An object should be coloured to show alternating contrasting bands if:

(a) it has essentially unbroken surfaces and has one dimension, horizontal or vertical, greater than 1.5m, and the other dimension, horizontal or vertical, less than 4.5m; or
(b) it is of skeletal type with either a vertical or a horizontal dimension greater than 1.5m.

The bands should be perpendicular to the longest dimension and have a width approximately 1/7 of the longest dimension or 30 m, whichever is less. The colours of the bands should contrast with the background against which they will be seen. Orange and white should be used, except where such colours are not conspicuous when viewed against the background. The bands on the extremities of the object should be of the darker colour. (See Figures 7-1 and 7-2.)

7.2.2.3 Table 7-1 shows a formula for determining band widths and for having an odd number of bands, thus permitting both the top and bottom bands to be of the darker colour.

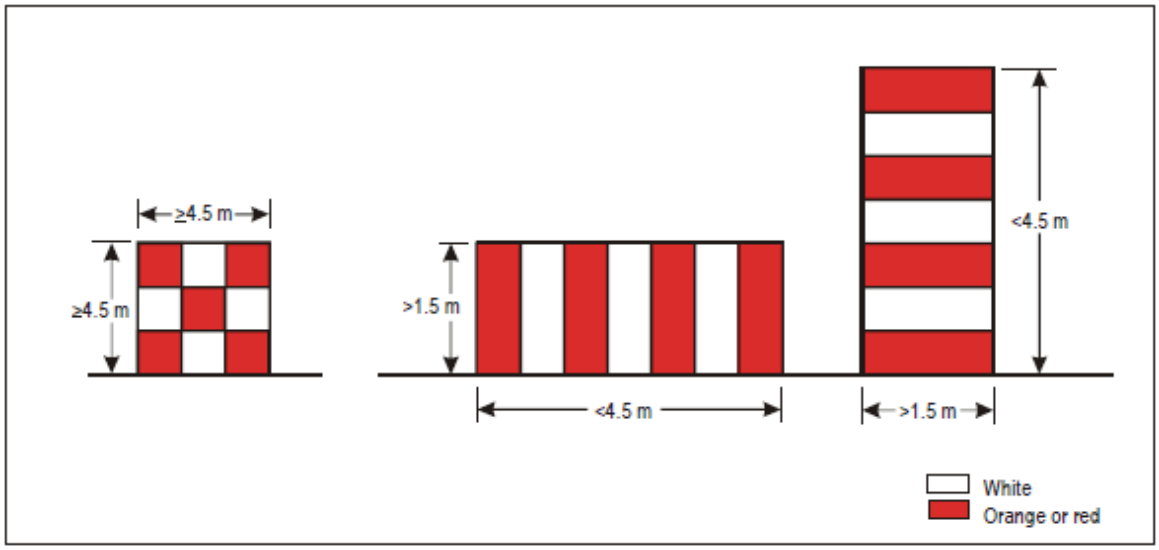

Figure 7-1: Basic marking patterns

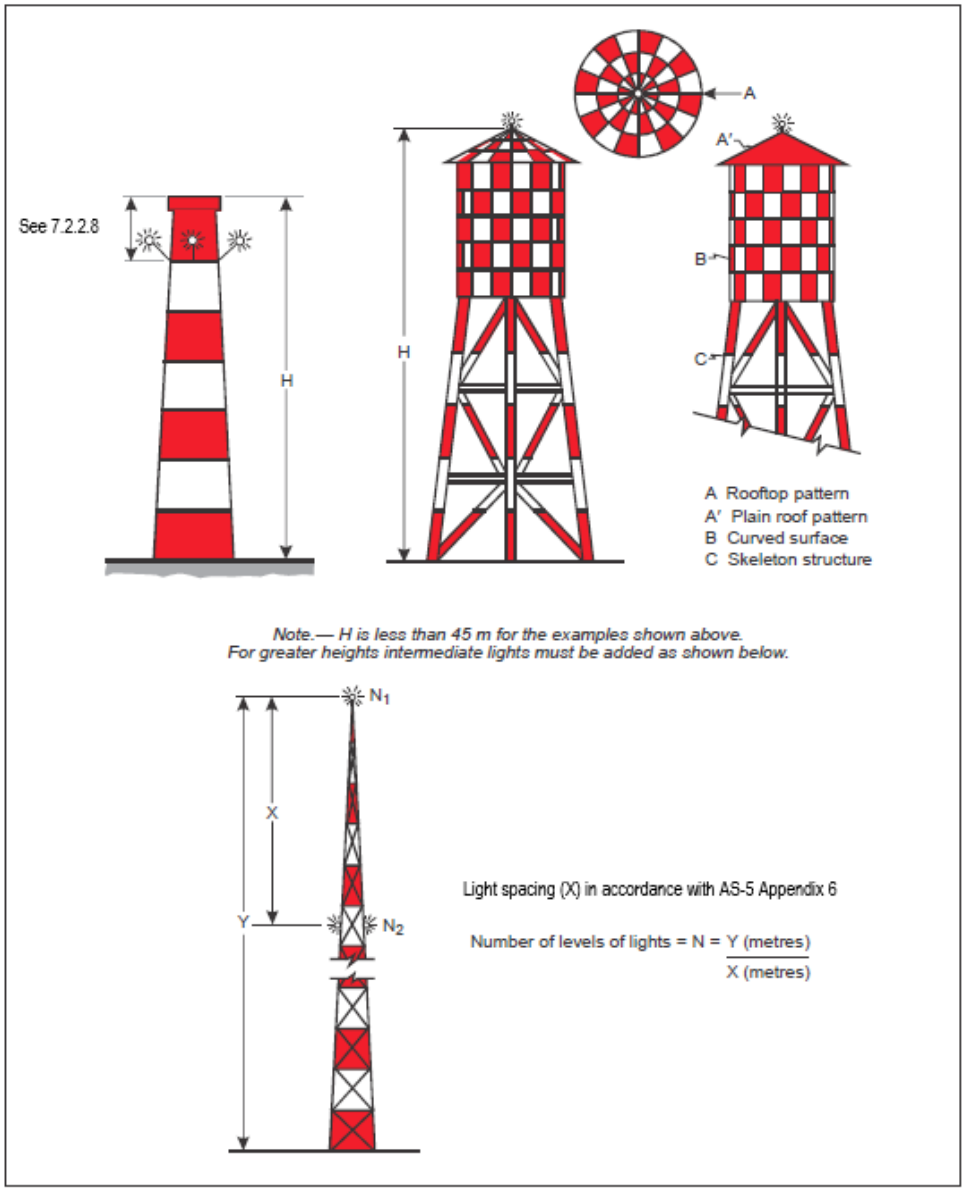

Figure 7-2: Examples of marking and lighting of tall structures

Table 7-1 – Marking band widths

Longest dimension		Band width
Greater than	Not exceeding	
1.5 m	210 m	1/7 of longest dimension
210 m	270 m	1/9 of longest dimension
270 m	330 m	1/11 of longest dimension
330 m	390 m	1/13 of longest dimension
390 m	450 m	1/15 of longest dimension
450 m	510 m	1/17 of longest dimension
510 m	570 m	1/19 of longest dimension
570 m	630 m	1/21 of longest dimension

7.2.2.4 An object should be coloured in a single conspicuous colour if its projection on any vertical plane has both dimensions less than 1.5m. Orange or red should be used, except where such colours merge with the background.

7.2.2.5 Against some backgrounds it may be found necessary to use a different colour from orange or red to obtain sufficient contrast.

Marking by flags

7.2.2.6 Flags used to mark fixed objects should be orange in colour or a combination of two triangular sections, one orange and the other white, or one red and the other white, except that where such colours merge with the background, other conspicuous colours should be used.

Marking by markers

7.2.2.7 A marker should be of one colour. When installed, white and red, or white and orange markers should be displayed alternately. The colour selected should contrast with the background against which it will be seen.

Lighting

7.2.2.8 In the case of chimney or other structure of like function, the top lights should be placed sufficiently below the top so as to minimize contamination by smoke, etc. (See Figure 7-2).

7.2.2.9 When the obstacle limitation surface concerned is sloping and the highest point above the OLS is not the highest point of the object, additional obstacle lights should be placed on the highest point of the object.

7.2.2.10 The installation setting angles for high-intensity obstacle lights, Type A, should be in accordance with Table 7-2.

7.2.2.11 High-intensity obstacle lights are intended for day use as well as night use. Care is needed to ensure that these lights do not create disconcerting dazzle. Guidance on the design, location and operation of high-intensity obstacle lights is given in the Aerodrome Design Manual (Doc 9157), Part 4.

7.2.2.12 Where, the use of high-intensity obstacle lights, Type A, or medium-intensity obstacle lights, Type A, at night may dazzle pilots in the vicinity of an aerodrome (within approximately 10 000 m radius) or cause significant environmental concerns, a dual obstacle lighting system should be provided. This system should be composed of high-intensity obstacle lights, Type A, or medium-intensity obstacle lights, Type A, as appropriate, for daytime and twilight use and medium-intensity obstacle lights, Type B or C, for night-time use.

Lighting of objects with a height less than 45 m above ground level

7.2.2.13 Low-intensity obstacle lights, Type A or B, should be used where the object is a less extensive one and its height above the surrounding ground is less than 45 m.

7.2.2.14 Where the use of low-intensity obstacle lights, Type A or B, would be inadequate or an early special warning is required, then medium- or high-intensity obstacle lights should be used.

7.2.2.15 Low-intensity obstacle lights, Type B, should be used either alone or in combination with medium-intensity obstacle lights, Type B, in accordance with paragraph 7.2.2.16.

7.2.2.16 Medium-intensity obstacle lights, Type A, B or C, should be used where the object is an extensive one. Medium-intensity obstacle lights, Types A and C, should be used alone, whereas medium-intensity obstacle lights, Type B, should be used either alone or in combination with low-intensity obstacle lights, Type B.

7.2.2.17 A group of buildings is regarded as an extensive object.

Lighting of objects with a height 45m to a height less than 150m above ground level

7.2.2.18 Medium-intensity obstacle lights, Type A, B or C, should be used. Medium-intensity obstacle lights, Types A and C, should be used alone, whereas medium-intensity obstacle lights, Type B, should be used either alone or in combination with low-intensity obstacle lights, Type B.

Lighting of objects with a height 150m or more above ground level

7.2.2.19 High-intensity obstacle lights, Type A, should be used to indicate the presence of an object if its height above the level of the surrounding ground exceeds 150m and an aeronautical study indicates such lights to be essential for the recognition of the object by day.

7.2.2.20 Where, the use of high-intensity obstacle lights, Type A, at night may dazzle pilots in the vicinity of an aerodrome (within approximately 10 000m radius) or cause significant environmental concerns, medium-intensity obstacle lights, Type C, should be used alone, whereas medium intensity obstacle lights, Type B, should be used either alone or in combination with low-intensity obstacle lights, Type B.

7.2.3 Wind turbines

Markings

7.2.3.1 The rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines should be painted white, unless otherwise indicated by an aeronautical study.

Lighting

7.2.3.2 When lighting is deemed necessary, in the case of a wind farm, i.e. a group of two or more wind turbines, the wind farm should be regarded as an extensive object and the lights should be installed:

(a) to identify the perimeter of the wind farm;
(b) respecting the maximum spacing, in accordance with AS-5 paragraph 9.2.3.8, between the lights along the perimeter, unless a dedicated assessment shows that a greater spacing can be used;
(c) so that, where flashing lights are used, they flash simultaneously throughout the wind farm;
(d) so that, within a wind farm, any wind turbines of significantly higher elevation are also identified wherever they are located; and
(e) at locations prescribed in (a), (b) and (d), respecting the following criteria:

(i) for wind turbines of less than 150m in overall height (hub height plus vertical blade height), medium-intensity lighting on the nacelle should be provided;

(ii) for wind turbines from 150m to 315m in overall height, in addition to the medium-intensity light installed on the nacelle, a second light serving as an alternate should be provided in case of failure of the operating light. The lights should be installed to assure that the output of either light is not blocked by the other; and

(iii) in addition, for wind turbines from 150m to 315m in overall height, an intermediate level at half the nacelle height of at least three low-intensity Type E lights, as specified in AS-5 paragraph 9.2.1.3, should be provided. If an aeronautical study shows that low-intensity Type E lights are not suitable, low-intensity Type A or B lights may be used.

7.2.3.3 The above paragraph 7.2.3.2(e) does not address wind turbines of more than 315m of overall height. For such wind turbines, additional marking and lighting may be required as determined by an aeronautical study.

7.2.3.4 The obstacle lights should be installed on the nacelle in such a manner as to provide an unobstructed view for aircraft approaching from any direction.

7.2.3.5 Where lighting is deemed necessary for a single wind turbine or short line of wind turbines, the installation should be in accordance with 7.2.3.2(e) or as determined by an aeronautical study.

7.2.4 Overhead wires, cables, etc., and supporting towers

Marking

7.2.4.1 The wires, cables, etc., to be marked should be equipped with markers; the supporting tower should be coloured.

Marking by colours

7.2.4.2 The supporting towers of overhead wires, cables, etc., that require marking should be marked in accordance with paragraphs 7.2.2.1 to 7.2.2.4 and AS-5 paragraph 9.2.3.1, except that the marking of the supporting towers may be omitted when they are lighted by high-intensity obstacle lights by day.

Marking by markers

7.2.4.3 A marker displayed on an overhead wire, cable, etc., should be spherical and have a diameter of not less than 60cm.

7.2.4.4 The spacing between two consecutive markers or between a marker and a supporting tower should be appropriate to the diameter of the marker, but in no case should the spacing exceed:

(a) 30m where the marker diameter is 60cm progressively increasing with the diameter of the marker to
(b) 35m where the marker diameter is 80cm and further progressively increasing to a maximum of
(c) 40m where the marker diameter is of at least 130cm.

Where multiple wires, cables, etc., are involved, a marker should be located not lower than the level of the highest wire at the point marked.

7.2.4.5 A marker should be of one colour. When installed, white and red, or white and orange markers should be displayed alternately. The colour selected should contrast with the background against which it will be seen.

7.2.4.6 When it has been determined that an overhead wire, cable, etc., needs to be marked but it is not practicable to install markers on the wire, cable, etc., then high-intensity obstacle lights, Type B, should be provided on their supporting towers.

Lighting

7.2.4.7 High-intensity obstacle lights, Type B, should be used to indicate the presence of a tower supporting overhead wires, cables, etc., where:

(a) an aeronautical study indicates such lights to be essential for the recognition of the presence of wires, cables, etc.; or
(b) it has not been found practicable to install markers on the wires, cables, etc.

7.2.4.8 High-intensity obstacle lights, Type B, indicating the presence of a tower supporting overhead wires, cables, etc., should flash sequentially; first the middle light, second the top light and last, the bottom light. The intervals between flashes of the lights should approximate the following ratios:

Flash interval between	Ratio of cycle time
middle and top light	*1/13*
top and bottom light	*2/13*
bottom and middle light	*10/13*

7.2.4.9 High-intensity obstacle lights are intended for day use as well as night use. Care is needed to ensure that these lights do not create disconcerting dazzle. Guidance on the design, operation and the location of high-intensity obstacle lights is given in the Aerodrome Design Manual (Doc 9157), Part 4.

7.2.4.10 Where, the use of high-intensity obstacle lights, Type B, at night may dazzle pilots in the vicinity of an aerodrome (within approximately 10 000m radius) or cause significant environmental concerns, a dual obstacle lighting system should be provided. This system should be composed of high-intensity obstacle lights, Type B, for daytime and twilight use and medium-intensity obstacle lights, Type B, for night time use. Where medium-intensity lights are used they should be installed at the same level as the high-intensity obstacle light Type B.

7.2.4.11 The installation setting angles for high-intensity obstacle lights, Type B, should be in accordance with Table 7-2.

Table 7-2 – Installation setting angles for high-intensity obstacle lights

Height of light unit above terrain (AGL)		Angle of the peak of the beam above the horizontal
Greater than	Not exceeding	
151m	-	0^o
122 m	151 m	1^o
92 m	122 m	2^o
-	92 m	3^o

8 GUIDANCE FOR CHAPTER 10 OF AS-5: VISUAL AIDS FOR DENOTING RESTRICTED USE AREAS

8.1 Closed runways and taxiways, or parts thereof

Application

8.1.1 A closed marking should be displayed on a temporarily closed runway or taxiway or portion thereof, except that such marking may be omitted when the closing is of short duration (less than 3 days) and adequate warning by air traffic services is provided.

8.2 Unserviceable areas

Characteristics of unserviceability cones

8.2.1 An unserviceability cone should be at least 0.5 m in height and red, orange or yellow or any one of these colours in combination with white.

8.2.2 An unserviceability marker board should be at least 0.5 m in height and 0.9 m in length, with alternate red and white or orange and white vertical stripes.

9 GUIDANCE FOR CHAPTER 11 OF AS-5: ELECTRICAL SYSTEMS

9.1 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.

Visual aids

9.2 At an aerodrome where the primary runway is a non-instrument runway, a secondary power supply for visual aids would not need to be provided when an emergency lighting system in accordance with the specification in paragraph 6.3.2 is provided and capable of being deployed in 15 minutes. See AS-5 paragraph 11.1.9.

Monitoring

9.3 For a runway meant for use in runway visual range conditions less than a value of 550m, the lighting systems detailed in AS-5 Table 11-1 should be monitored automatically to provide an indication when the serviceability level of any element falls below the minimum level below which operations should not continue. This information should be automatically relayed to the air traffic services unit and displayed in a prominent position.

9.4 Guidance on air traffic control interface and visual aids monitoring is included in the ICAO Aerodrome Design Manual (Doc 9157), Part 5.

10 GUIDANCE FOR CHAPTER 12 OF AS-5: AERODROME OPERATIONAL SERVICES, EQUIPMENT AND INSTALLATIONS

10.1 Rescue and firefighting

10.1.1 The level of protection provided at an aerodrome for rescue and firefighting should be equal to the aerodrome category determined using the principles in AS-5 paragraphs 12.1.2 and 12.1.3.

Extinguishing agents

10.1.2 The complementary extinguishing agent should be a dry chemical powder suitable for extinguishing hydrocarbon fires.

10.1.3 When selecting dry chemical powders for use with foam, care must be exercised to ensure compatibility.

10.1.4 Alternate complementary agents having equivalent firefighting capability may be utilized. Additional information on extinguishing agents is given in the ICAO Airport Services Manual, Part 1.

10.1.5 Dry chemical powders should only be substituted with an agent that has equivalent or better firefighting capabilities, for all types of fires where complementary agent is expected to be used.

10.1.6 Guidance on the use of complementary agents can be found in the Airport Services Manual (Doc 9137), Part 1.

10.1.7 Where a major delay in the replenishment of the supplies is anticipated, the amount of reserve supply in AS-5 paragraphs 12.1.16, 12.1.17 and 12.1.18 should be increased as determined by a risk assessment.

10.1.8 See ICAO Airport Services Manual (Doc 9137), Part 1 for guidance on the conduct of a risk analysis to determine the quantities of reserve extinguishing agents.

Response time

10.1.9 To meet the operational objective as nearly as possible in less than optimum conditions of visibility, especially during low visibility operations, suitable guidance, equipment and/or procedures for rescue and firefighting services should be provided.

10.1.10 Additional guidance is available in the ICAO Airport Services Manual, Part 1.

Emergency access roads

10.1.11 When the surface of the road is indistinguishable from the surrounding area, edge markers should be placed at intervals of about 10m.

10.2 Other special services

10.2.1 An aerodrome operator should establish procedures to deal with fuel spillage, hot-works and other special services associated with fire risks.

10.3 Apron management service

10.3.1 When the ATS provider does not participate in the apron management service, procedures should be established to facilitate the orderly transition of aircraft between the apron management unit and the aerodrome control tower.

10.3.2 Procedures on apron safety are specified in the PANS-Aerodromes (Doc 9981). Guidance on an apron management service is given in the Airport Services Manual (Doc 9137), Part 8, and in the Manual of Surface Movement Guidance and Control Systems (SMGCS) (Doc 9476).

10.3.3 An aircraft should be allocated to an aircraft stand or apron area appropriate to the aircraft characteristics.

10.3.4 A risk assessment should be carried out if there is a need to allocate aircraft parking to areas other than aircraft stands or apron areas. The need to allocate aircraft to other areas could arise from situations such as mass diversions, special events, adverse weather conditions, contingency requirements, work in progress, etc.

10.3.5 When allocating an aircraft to an aircraft stand, the following parameters should be considered:

(a) parking aids;

(b) facilities serving the aircraft stand;

(c) proximity of infrastructure;

(d) other parked aircraft in the neighbouring aircraft stands;

(e) aircraft stand dependencies; and

(f) jet blast and propeller wash related protection

10.4 Surface movement guidance and control systems

10.4.1 Guidance on surface movement guidance and control systems is contained in the ICAO Manual of Surface Movement Guidance and Control Systems (SMGCS) (Doc 9476). Guidance on advanced surface movement guidance and control systems is contained in the ICAO Manual of Advanced Surface Movement Guidance and Control Systems (A-SMGCS) (Doc 9830).

10.4.2 Guidance on control of stop bars through induction loops and on a visual taxiing guidance and control system is contained in the Aerodrome Design Manual (Doc 9157), Part 4.

Application

10.4.3 The design of a surface movement guidance and control system should take into account:

(a) the density of air traffic;
(b) the visibility conditions under which operations are intended;
(c) the need for pilot orientation;
(d) the complexity of the aerodrome layout; and
(e) movements of vehicles.

10.4.4 Surface movement radar for the manoeuvring area should be provided at an aerodrome intended for use in runway visual range conditions less than a value of 350m.

10.4.5 Surface movement radar for the manoeuvring area should be provided at an aerodrome other than that in paragraph 10.4.4 when traffic density and operating conditions are such that regularity of traffic flow cannot be maintained by alternative procedures and facilities.

10.4.6 Guidance on the use of surface movement radar is given in the ICAO Manual of Surface Movement Guidance and Control Systems (SMGCS)(Doc 9476) and in the ICAO Air Traffic Services Planning Manual (Doc 9426).

10.5 Siting of equipment and installations on operational areas

10.5.1 Requirements for obstacle limitation surfaces are specified in AS-5 paragraph 7.2.

10.5.2 Guidance on the frangible design of visual and non-visual aids for navigation is given in the Aerodrome Design Manual (Doc 9157), Part 6.

10.5.3 Any equipment or installation required for air navigation purposes which is an obstacle of operational significance in accordance with AS-5 paragraph 7.2.4 and paragraphs 5.3.4, 5.3.7 and 5.3.13 should be frangible and mounted as low as possible.

10.6 Fencing

Location

10.6.1 When greater security is thought necessary, a cleared area should be provided on both sides of the fence or barrier to facilitate the work of patrols and to make trespassing more difficult. Consideration should be given to the provision of a perimeter road inside the aerodrome fencing for the use of both maintenance personnel and security patrols.

11 GUIDANCE FOR CHAPTER 13 OF AS-5: AERODROME MAINTENANCE

11.1 General

11.1.1 Preventive maintenance is programmed maintenance work done in order to prevent a failure or degradation of facilities which include 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.

11.1.3 Guidance material on Human Factors principles can be found in the ICAO Human Factors Training Manual (Doc 9683) and ICAO Airport Service Manual (Doc 9137), Part 8 – Airport Operational Services.

11.1.4 General principles and procedures on the training of aerodrome personnel, including training programmes and competence checks, are specified in the PANS-Aerodromes (Doc 9981).

11.2 Pavements

11.2.1 The runway surface should be visually assessed, as necessary, under natural or simulated rain conditions for ponding or poor drainage and where required, corrective maintenance action taken.

11.2.2 When a taxiway is used by turbine-engined aeroplanes, the surface of the taxiway shoulders should be maintained so as to be free of any loose stones or other objects that could be ingested by the aeroplane engines. Guidance on this is given in the ICAO Aerodrome Design Manual (Doc 9157), Part 2.

11.3 Runway pavement overlays

11.3.1 Overlaying should proceed from one end of the runway toward the other end so that based on runway utilization most aircraft operations will experience a down ramp.

11.3.2 The entire width of the runway should be overlaid during each work session.

11.3.3 The overlay should be constructed and maintained above the minimum friction level specified in AS-5 paragraph 13.1.3.

11.4 Visual aids

11.4.1 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.

11.4.2 Enhanced vision systems (EVS) technology relies on the infra-red heat signature provided by incandescent lighting. ICAO Annex 15 protocols provide an appropriate means of notifying aerodrome users of EVS when lighting systems are converted to LED.

11.4.3 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 the air traffic control unit.

11.4.4 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 AS-5 Appendix 3.

11.4.5 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.

11.4.6 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.

12 GUIDANCE FOR APPENDIX 2 OF AS-5: COLOURS FOR AERONAUTICAL GROUND LIGHTS, MARKINGS, SIGNS AND PANELS

12.1 Colours for aeronautical ground lights

12.1.1 Chromaticities for lights having filament-type light sources

12.1.1.1 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 $y = 0.390 – 0.171x$

Where the colour signal is to be seen from long range, it has been the practice to use colours within the abovementioned boundaries.

12.1.1.2 Where increased certainty of recognition from white is more important than maximum visual range, green signals should be within the following boundaries:

Yellow boundary $y = 0.726 – 0.726x$
White boundary $x = 0.625y – 0.041$
Blue boundary $y = 0.390 – 0.171x$

12.1.2 Discrimination between lights having filament-type sources

12.1.2.1 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.

12.1.2.2 If there is a requirement to discriminate yellow from green and/or white[2], as for example on exit taxiway centre line lights, the y coordinates of the yellow light should not exceed a value of 0.40.

12.1.2.3 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.

12.1.3 Chromaticities for lights having a solid-state light source

12.1.3.1 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 = 0.625y – 0.041
Blue boundary y = 0.400

12.1.3.2 In order to avoid a large variation of shades of green, if colours within the boundaries below are selected, colours within the boundaries of 12.1.3.1 should not be used.

Yellow boundary x = 0.310
White boundary x = 0.625y – 0.041
Blue boundary y = 0.726 – 0.726x

12.2 Colours for markings, signs and panels

12.2.1 The chromaticity and luminance factors of ordinary colours for markings and externally illuminated signs and panels should be within the following boundaries when determined under standard conditions:

CIE Equations (see AS-5 Figure A2-2):

(a) Red
Purple boundary y = 0.345 – 0.051x
White boundary y = 0.910 – x
Orange boundary y = 0.314 + 0.047x
Luminance factor ß = 0.07 (minimum)

(b) Orange
Red boundary y = 0.285 + 0.100x
White boundary y = 0.940 – x
Yellow boundary y = 0.250 + 0.220x
Luminance factor ß = 0.20 (minimum)

[2] 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.

(c) Yellow
Orange boundary y = 0.108 + 0.707x
White boundary y = 0.910 – x
Green boundary y = 1.35x – 0.093
Luminance factor ß = 0.45 (minimum)

(d) White
Purple boundary y = 0.010 + x
Blue boundary y = 0.610 – x
Green boundary y = 0.030 + x
Yellow boundary y = 0.710 – x
Luminance factor ß = 0.75 (minimum)

(e) Black
Purple boundary y = x – 0.030
Blue boundary y = 0.570 – x
Green boundary y = 0.050 + x
Yellow boundary y = 0.740 – x
Luminance factor ß = 0.03 (maximum)

(f) Yellowish green
Green boundary y = 1.317x + 0.4
White boundary y = 0.910 – x
Yellow boundary y = 0.867x + 0.4

(g) Green
Yellow boundary x = 0.313
White boundary y = 0.243 + 0.670x
Blue boundary y = 0.493 – 0.524x
Luminance factor β = 0.10 (minimum)

12.2.2 The small separation between surface red and surface orange is not sufficient to ensure the distinction of these colours when seen separately.

12.2.3 The chromaticity and luminance factors of colours of retroreflective materials for markings, signs and panels should be within the following boundaries when determined under standard conditions.

CIE Equations (see Figure 12-1):

(a) Red
Purple boundary y = 0.345 – 0.051x
White boundary y = 0.910 – x
Orange boundary y = 0.314 + 0.047x
Luminance factor ß = 0.03 (minimum)

(b) Orange
Red boundary y = 0.265 + 0.205x
White boundary y = 0.910 – x
Yellow boundary y = 0.207 + 0.390x

Luminance factor ß = 0.14 (minimum)

(c) Yellow
Orange boundary y = 0.160 + 0.540x
White boundary y = 0.910 – x
Green boundary y = 1.35x – 0.093
Luminance factor ß = 0.16 (minimum)

(d) White
Purple boundary y = x
Blue boundary y = 0.610 – x
Green boundary y = 0.040 + x
Yellow boundary y = 0.710 – x
Luminance factor ß = 0.27 (minimum)

(e) Blue
Green boundary y = 0.118 + 0.675x
White boundary y = 0.370 – x
Purple boundary y = 1.65x – 0.187
Luminance factor ß = 0.01 (minimum)

(f) Green
Yellow boundary y = 0.711 – 1.22x
White boundary y = 0.243 + 0.670x
Blue boundary y = 0.405 – 0.243x
Luminance factor ß = 0.03 (minimum)

12.2.4 The chromaticity and luminance factors of colours for luminescent or transilluminated (internally illuminated) signs and panels[3] should be within the following boundaries when determined under standard conditions.

CIE Equations (see Figure 12-2):

(a) Red
Purple boundary y = 0.345 – 0.051x
White boundary y = 0.910 – x
Orange boundary y = 0.314 + 0.047x
Luminance factor (day condition) ß = 0.07 (minimum)
Relative luminance to white (night condition): 5% (minimum) - 20% (maximum)

(b) Yellow
Orange boundary y = 0.108 + 0.707x
White boundary y = 0.910 – x
Green boundary y = 1.35x – 0.093
Luminance factor (day condition) ß = 0.45 (minimum)
Relative luminance to white (night condition): 30% (minimum) - 80% (maximum)

[3] The specifications for transilluminated panels are interim in nature and are based on the CIE specifications for transilluminated signs. It is intended that these specifications will be reviewed and updated as and when CIE develops specifications for transilluminated panels.

(c) White
Purple boundary y = 0.010 + x
Blue boundary y = 0.610 – x
Green boundary y = 0.030 + x
Yellow boundary y = 0.710 – x
Luminance factor (day condition) ß = 0.75 (minimum)
Relative luminance to white (night condition): 100%

(d) Black
Purple boundary y = x – 0.030
Blue boundary y = 0.570 – x
Green boundary y = 0.050 + x
Yellow boundary y = 0.740 – x
Luminance factor (day condition) ß = 0.03 (maximum)
Relative luminance to white (night condition): 0% (minimum) - 2% (maximum)

(e) Green
Yellow boundary : x = 0.313
White boundary: y = 0.243 + 0.670x
Blue boundary: y = 0.493 – 0.524x
Luminance factor (day conditions) β = 0.10 minimum
Relative luminance to white (night conditions): 5% (minimum) - 30% (maximum)

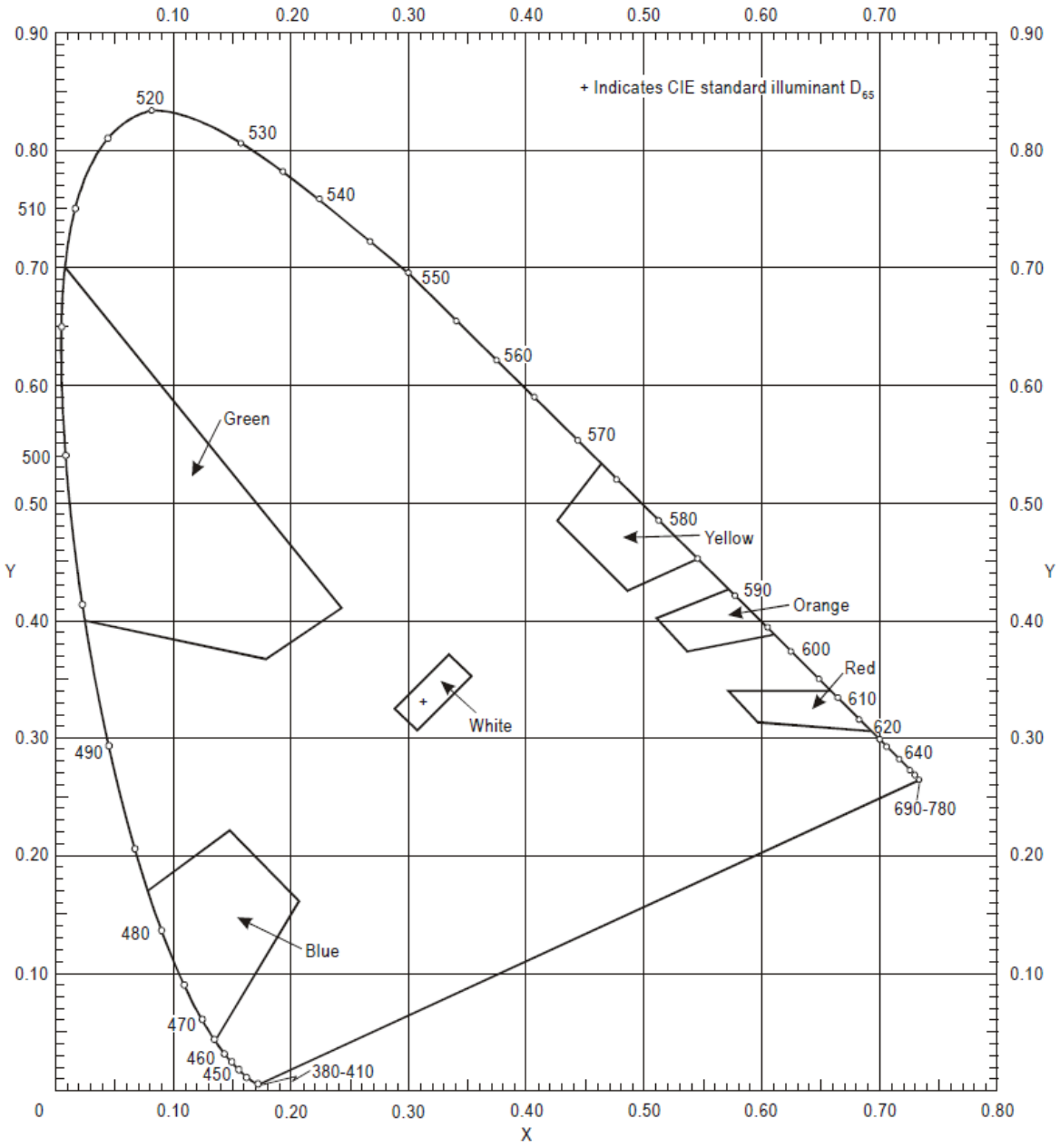

Figure 12-1. Colours of retroreflective materials for markings, signs and panels

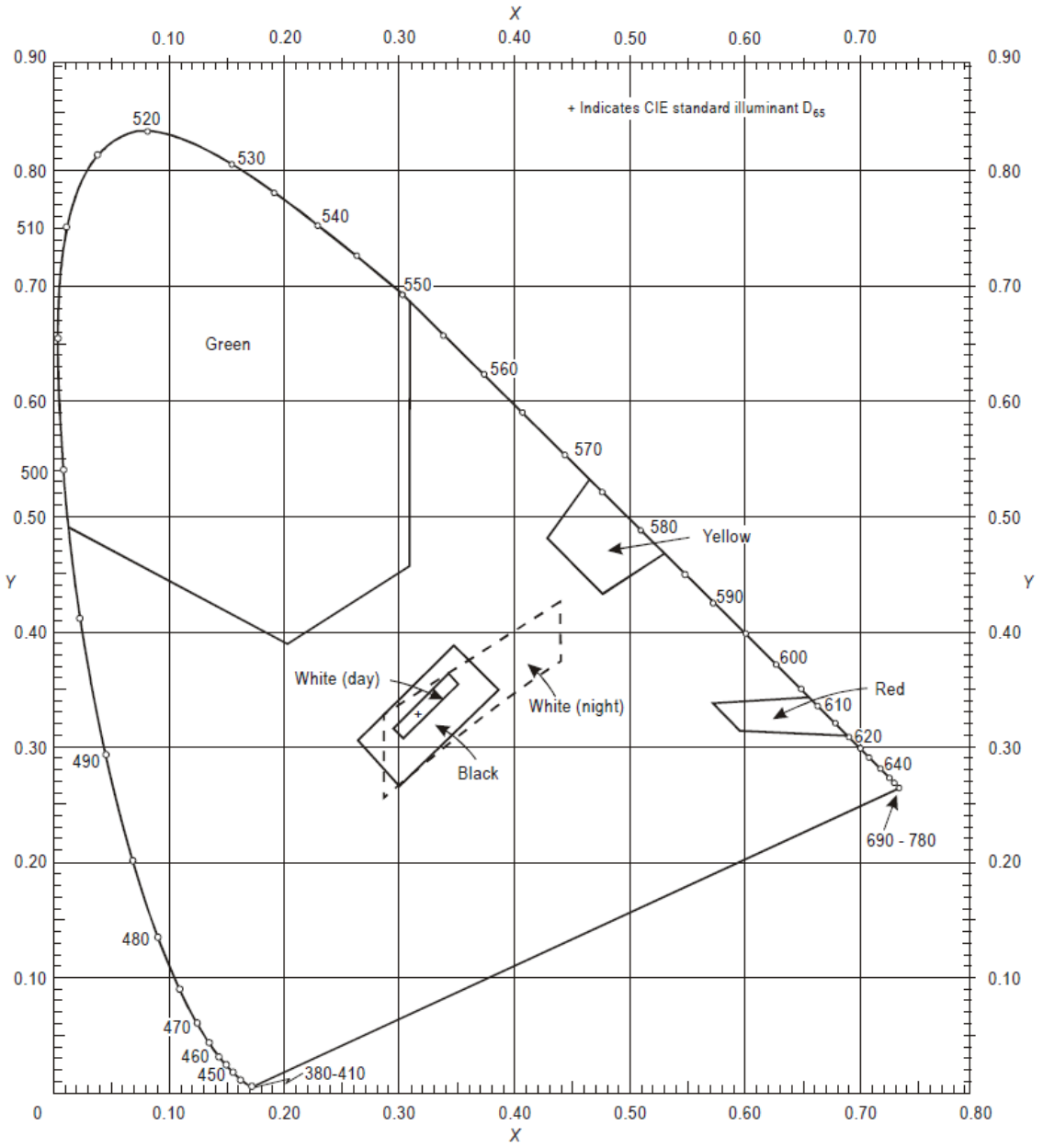

Figure 12-2. Colours of luminescent or transilluminated (internally illuminated) signs and panels

APPENDIX 1: MITIGATING MEASURES TO REDUCE PROBABILITY AND SEVERITY OF AIRCRAFT UNDERSHOOTING OR OVERRUNNING A RUNWAY AT AN AERODROME

A1 Aeronautical Study or Risk Assessment

A1.1 The risk of an aircraft undershooting or overshooting a runway should be assessed through an aeronautical study or risk assessment, where the RESA does not extend to the recommended distance for the runway code number. See AS-5 paragraph 6.5.2 and paragraph 4.6.2 on the RESA.

A2 Mitigating Measures

A2.1 Mitigating measures should be put in place to eliminate the risks identified in the aeronautical study or risk assessment mentioned in Section 3 of this Appendix. In many cases where risks identified could not be eliminated, they should at least be reduced to a level that is as low as reasonably practicable.

A2.2 The operator should adopt mitigating measures, singly or in combination to reduce the risks of an aircraft undershooting or overrunning a runway.

A2.3 Mitigating measures to manage the likelihood that either an undershoot or overrun might occur (also referred to as “Probability”) include:

(a) Ensure an open communication between the aerodrome operator, air navigation service provider and aircraft operators to raise awareness of the factors that could lead to a runway excursion and to discuss and implement mitigating measures for such events;
(b) Put in place a maintenance programme for runway such that the runway will be inspected, and their conditions monitored regularly;
(c) Improve runway friction characteristics;
(d) Set higher friction levels for:
(i) Maintenance friction level below which corrective maintenance action should be initiated; and
(ii) Minimum friction level below which information that a runway may be slippery when wet should be made available.
(e) Ensure accurate and up-to-date information on weather and runway conditions is made available to pilots and the maintenance personnel;
(f) During runway maintenance works, ensure that any temporary reduced declared distances are clearly communicated to pilots and that any visual aids correspond to the actual declared distances are available;
(g) During runway resurfacing projects, ensure that accurate information regarding the condition of the runway surface is effectively promulgated to pilots;
(h) In consultation with aircraft operators and air navigation service providers formulate procedures to help ensure stabilised approaches;
(i) In consultation with aircraft operators and air navigation service providers consider operating procedures or restrictions for inclement weather conditions.

A2.4 Mitigating measures to manage the possible consequences of either an undershoot or overrun, taking as reference the worst foreseeable situation (also referred to as "Severity") include:

(a) Reduce the declared distances in order to provide an increased length of RESA. Aerodrome operator should consult the aircraft operators to determine what effects it would have on their operations;
(b) In the case where the runway has a displaced threshold, examine whether the threshold can be moved (downwind) to increase the RESA;
(c) Eliminate obstacles in the area beyond the RESA. In cases where it is not possible to eliminate the obstacles, they should be assessed for its purposes and make frangible whenever possible;
(d) Improve the slopes in the RESA to minimise or remove downward slopes if any;
(e) Provide paved RESA with good friction characteristics;
(f) Consider land acquisition and realigning fences or roads to provide additional length of RESA.

A3 Review of Aeronautical Study or Risk Assessment

A3.1 Aerodrome operators should review their aeronautical study or risk assessment regularly and whenever significant changes occur that would affect either the probability or severity of an undershoot or overrun.

A3.2 Changes include but are not limited to the following:

(a) Changes to the declared distances;
(b) New or larger aircraft types operating at the aerodrome;
(c) Changes to the number of aircraft movements at the aerodrome;
(d) Changes to the air traffic mix;
(e) Runway closures for maintenance or projects near the end of a runway.

A3.3 Any changes to the aeronautical study or risk assessment should be evaluated and properly documented.