OVERSEAS TERRITORIES AVIATION REQUIREMENTS (OTARs)

Part 191

DESIGN OF AERODROMES

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Revisions

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Subpart A – General

191.1 Purpose

(a) The requirements of this OTAR Part prescribe the requirements governing the design of an aerodrome requiring to be certificated under the Order.

(b) These Requirements are not in themselves Law. Failure to comply may not constitute an offence. However, the Requirements repeat or reproduce many of the provisions of the Air Navigation (Overseas Territories) Order 2007 (as amended) ("the Order"), including the Rules of the Air set out in Schedule 8 to the Order. Therefore, failure to comply with these Requirements may:

(1) constitute a breach of the Order; and

(2) result in proceedings for breaches of the Order; or

(3) result in the refusal of an application for renewal of a certificate or licence; or

(4) result in action to suspend or revoke a certificate or licence.

(c) The Order details the legal obligations governing the certification of aerodromes but specifies these obligations in rather general terms. Therefore, there is a provision in the Order which requires the Governor to publish Requirements to augment, amplify and detail more precisely the manner in which these obligations shall be met. The Requirements are the means by which the aerodrome operator will be able to satisfy the Governor as to the fulfilment of the obligations in respect of the entitlement to hold and exercise the privileges of an aerodrome certificate.

(d) The issue of a certificate shows only that the holder is considered competent to ensure the safe and secure operation of an aerodrome in accordance with the Aerodrome Manual and, where applicable, the Airport Security Programme. The possession of a certificate, Aerodrome Manual or Airport Security Programme does not relieve the aerodrome certificate holder from the responsibility for compliance with the Order and any other legislation in force. Neither does it relieve them of their responsibility for oversight of any service provider contracted by them to meet the requirements applied to them.

(e) Other OTAR Parts may impinge upon activities conducted under this Part. In particular, Part 1 contains definitions which apply, unless otherwise stated, to all Parts. A full list of OTAR Parts, a description of the legislative structure and the place of OTARs and Overseas Territory Aviation Circulars (OTACs) within it can be viewed on the ASSI website www.airsafety.aero. OTACs relevant to this Part can be viewed at [include to link to relevant OTAC page].

(f) References to the Governor in this OTAR Part mean the regulator designated by the Governor of the Territory to exercise their functions under the Order.

191.3 Use of English

All documentation, written communications and data (electronic or otherwise) for submission to the Governor in support of an application for a approval shall be provided in English.

191.5 Power to inspect

(a) The holder of an aerodrome certificate shall ensure that any person authorised by the Governor is allowed access to an aerodrome or place where an aircraft has taken off or landed.

(b) The holder of an aerodrome certificate shall ensure that any person authorised by the Governor shall have access to any documentation pertinent to the certification of the aerodrome. The holder of a certificate shall handle any documentation ensuring that, if requested to do so by an authorised person, it is produced within a reasonable period.

(c) Each aerodrome certificate holder shall comply with any request by the Governor for a practical demonstration or test to verify compliance with the OTARs.

191.7 Definitions

The definitions used throughout this Part are in accordance with OTAR Part 1. Additionally, in this Part:

Aerodrome - A defined area on land or water (including any buildings, installations and equipment) intended to be used either wholly or in part for the arrival, departure and surface movement of aircraft.

Aerodrome beacon - Aeronautical beacon used to indicate the location of an aerodrome from the air.

Aerodrome certificate - A certificate issued by the appropriate authority under applicable regulations for the operation of an aerodrome.

Aerodrome elevation - The elevation of the highest point of the landing area.

Aerodrome identification sign - A sign placed on an aerodrome to aid in identifying the aerodrome from the air.

Aerodrome mapping data (AMD) - Data collected for the purpose of compiling aerodrome mapping information for aeronautical uses.

Note: Aerodrome mapping data are collected for purposes that include the improvement of the situational awareness of the user, surface navigation operations, training, charting and planning.

Aerodrome mapping database (AMDB) - A collection of aerodrome mapping data organized and arranged as a structured data set.

Aerodrome reference point - The designated geographical location of an aerodrome.

Aerodrome traffic density:

a) **Light** - Where the number of movements in the mean busy hour is not greater than 15 per runway or typically less than 20 total aerodrome movements.

b) **Medium** - Where the number of movements in the mean busy hour is of the order of 16 to 25 per runway or typically between 20 to 35 total aerodrome movements.

c) **Heavy** - Where the number of movements in the mean busy hour is of the order of 26 or more per runway or typically more than 35 total aerodrome movements.

Note 1: The number of movements in the mean busy hour is the arithmetic mean over the year of the number of movements in the daily busiest hour.

Note 2: Either a take-off or a landing constitutes a movement.

Aeronautical beacon - An aeronautical ground light visible at all azimuths, either continuously or intermittently, to designate a particular point on the surface of the earth.

Aeronautical ground light - Any light specially provided as an aid to air navigation, other than a light displayed on an aircraft.

Aeroplane reference field length - The minimum field length required for take-off at maximum certificated take-off mass, sea level, standard atmospheric conditions, still air and zero runway slope, as shown in the appropriate aeroplane flight manual prescribed by the certificating authority or equivalent data from the aeroplane manufacturer. Field length means balanced field length for aeroplanes, if applicable, or take-off distance in other cases.

Note: Attachment A, Section 2, provides information on the concept of balanced field length and the Airworthiness Manual (Doc 9760) contains detailed guidance on matters related to take-off distance.

Aircraft classification number (ACN) - A number expressing the relative effect of an aircraft on a pavement for a specified standard subgrade category.

Note: The aircraft classification number is calculated with respect to the centre of gravity (CG) position which yields the critical loading on the critical gear. Normally the aftmost CG position appropriate to the maximum gross apron (ramp) mass is used to calculate the ACN. In exceptional cases the forwardmost CG position may result in the nose gear loading being more critical.

Aircraft stand - A designated area on an apron intended to be used for parking an aircraft.

Apron - A defined area, on a land aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking or maintenance.

Apron management service - A service provided to regulate the activities and the movement of aircraft and vehicles on an apron.

Arresting system - A system designed to decelerate an aeroplane overrunning the runway.

Autonomous runway incursion warning system (ARIWS) - A system which provides autonomous detection of a potential incursion or of the occupancy of an active runway and a direct warning to a flight crew or a vehicle operator.

Baulked landing - A landing manoeuvre that is unexpectedly discontinued at any point below the obstacle clearance altitude/height (OCA/H).

Barrette - Three or more aeronautical ground lights closely spaced in a transverse line so that from a distance they appear as a short bar of light.

Calendar - Discrete temporal reference system that provides the basis for defining temporal position to a resolution of one day (ISO 19108).

Certified aerodrome - An aerodrome whose operator has been granted an aerodrome certificate.

Clearway - A defined rectangular area on the ground or water under the control of the appropriate authority, selected or prepared as a suitable area over which an aeroplane may make a portion of its initial climb to a specified height.

Cyclic redundancy check (CRC) - A mathematical algorithm applied to the digital expression of data that provides a level of assurance against loss or alteration of data.

Data accuracy - A degree of conformance between the estimated or measured value and the true value.

Data integrity (assurance level) - A degree of assurance that an aeronautical data and its value has not been lost or altered since the origination or authorized amendment.

Data quality - A degree or level of confidence that the data provided meet the requirements of the data user in terms of accuracy, resolution and integrity (or equivalent assurance level), traceability, timeliness, completeness and format.

Datum - Any quantity or set of quantities that may serve as a reference or basis for the calculation of other quantities (ISO 19104).

De-icing/anti-icing facility - A facility where frost, ice or snow is removed (de-icing) from the aeroplane to provide clean surfaces, and/or where clean surfaces of the aeroplane receive protection (anti-icing) against the formation of frost or ice and accumulation of snow or slush for a limited period of time.

Note: Further guidance is given in the Manual of Aircraft Ground De-icing/Anti-icing Operations (Doc 9640).

De-icing/anti-icing pad - An area comprising an inner area for the parking of an aeroplane to receive de-icing/anti-icing treatment and an outer area for the manoeuvring of two or more mobile de-icing/anti-icing equipment.

Declared distances:

a) **Take-off run available (TORA) -** The length of runway declared available and suitable for the ground run of an aeroplane taking off.

b) **Take-off distance available (TODA)** - The length of the take-off run available plus the length of the clearway, if provided.

c) **Accelerate-stop distance available (ASDA)** - The length of the take-off run available plus the length of the stopway, if provided.

d) **Landing distance available (LDA)** - The length of runway which is declared available and suitable for the ground run of an aeroplane landing.

Displaced threshold - A threshold not located at the extremity of a runway.

Dynamic load-bearing surface - A surface capable of supporting the loads generated by a helicopter in motion.

Effective intensity - The effective intensity of a flashing light is equal to the intensity of a fixed light of the same colour which will produce the same visual range under identical conditions of observation.

Ellipsoid height (Geodetic height) - The height related to the reference ellipsoid, measured along the ellipsoidal outer normal through the point in question.

Fixed light - A light having constant luminous intensity when observed from a fixed point.

Foreign object debris (FOD) - An inanimate object within the movement area which has no operational or aeronautical function, and which has the potential to be a hazard to aircraft operations.

Frangible object - An object of low mass designed to break, distort or yield on impact so as to present the minimum hazard to aircraft.

Note: Guidance on design for frangibility is contained in the Aerodrome Design Manual (Doc 9157), Part 6.

Geodetic datum - A minimum set of parameters required to define location and orientation of the local reference system with respect to the global reference system/frame.

Geoid - The equipotential surface in the gravity field of the Earth which coincides with the undisturbed mean sea level (MSL) extended continuously through the continents.

Note: The geoid is irregular in shape because of local gravitational disturbances (wind tides, salinity, current, etc.) and the direction of gravity is perpendicular to the geoid at every point.

Geoid undulation - The distance of the geoid above (positive) or below (negative) the mathematical reference ellipsoid.

Note: In respect to the World Geodetic System — 1984 (WGS-84) defined ellipsoid, the difference between the WGS-84 ellipsoidal height and orthometric height represents WGS-84 geoid undulation.

Gregorian calendar - Calendar in general use; first introduced in 1582 to define a year that more closely approximates the tropical year than the Julian calendar (ISO 19108).

Note: In the Gregorian calendar, common years have 365 days and leap years 366 days divided into twelve sequential months.

Hazard beacon - An aeronautical beacon used to designate a danger to air navigation.

Holding bay - A defined area where aircraft can be held, or bypassed, to facilitate efficient surface movement of aircraft.

Holdover time - The estimated time the anti-icing fluid (treatment) will prevent the formation of ice and frost and the accumulation of snow on the protected (treated) surfaces of an aeroplane.

Hot spot - A location on an aerodrome movement area with a history or potential risk of collision or runway incursion, and where heightened attention by pilots/drivers is necessary.

Human Factors principles - Principles which apply to aeronautical design, certification, training, operations, and maintenance and which seek safe interface between the human and other system components by proper consideration to human performance.

Human performance - Human capabilities and limitations which have an impact on the safety and efficiency of aeronautical operations.

Identification beacon - An aeronautical beacon emitting a coded signal by means of which a particular point of reference can be identified.

Instrument runway - One of the following types of runways intended for the operation of aircraft using instrument approach procedures:

a) **Non-precision approach runway** - A runway served by visual aids and non-visual aid(s) intended for landing operations following an instrument approach operation type A and a visibility not less than 1 000 m.

b) **Precision approach runway, category I** - A runway served by visual aids and non-visual aid(s) intended for landing operations following an instrument approach operation type B with a decision height (DH) not lower than 60 m (200 ft) and either a visibility not less than 800 m or a runway visual range (RVR) not less than 550 m.

c) **Precision approach runway, category II** - A runway served by visual aids and non-visual aid(s) intended for landing operations following an instrument approach operation type B with a decision height (DH) lower than 60 m (200 ft) but not lower than 30 m (100 ft) and a (RVR)not less than 300 m.

d) **Precision approach runway, category III** - A runway served by visual aids and non-visual aid(s) intended for landing operations following an instrument approach operation type B with a decision height (DH) lower than 30 m (100 ft), or no decision height and a RVR less than 300 m, or no RVR limitations.

Note 1: Visual aids need not necessarily be matched to the scale of non-visual aids provided. The criterion for the selection of visual aids is the conditions in which operations are intended to be conducted.

Note 2: Refer to Annex 6 — Operation of Aircraft for instrument approach operation types.

Integrity classification (aeronautical data) - Classification based upon the potential risk resulting from the use of corrupted data. Aeronautical data is classified as:

a) **routine data:** there is a very low probability when using corrupted routine data that the continued safe flight and landing of an aircraft would be severely at risk with the potential for catastrophe,

b) **essential data:** there is a low probability when using corrupted essential data that the continued safe flight and landing of an aircraft would be severely at risk with the potential for catastrophe; and

c) **critical data:** there is a high probability when using corrupted critical data that the continued safe flight and landing of an aircraft would be severely at risk with the potential for catastrophe.

Intermediate holding position - A designated position intended for traffic control at which taxiing aircraft and vehicles shall stop and hold until further cleared to proceed, when so instructed by the aerodrome control tower.

Landing area - That part of a movement area intended for the landing or take-off of aircraft.

Landing direction indicator - A device to indicate visually the direction currently designated for landing and for take-off.

Laser-beam critical flight zone (LCFZ) - Airspace in the proximity of an aerodrome but beyond the LFFZ where the irradiance is restricted to a level unlikely to cause glare effects.

Laser-beam free flight zone (LFFZ) - Airspace in the immediate proximity of the aerodrome where the irradiance is restricted to a level unlikely to cause any visual disruption.

Laser-beam sensitive flight zone (LSFZ) - Airspace outside, and not necessarily contiguous with, the LFFZ and LCFZ where the irradiance is restricted to a level unlikely to cause flash-blindness or after-image effects.

Lighting system reliability - The probability that the complete installation operates within the specified tolerances and that the system is operationally usable.

Manoeuvring area - That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, excluding aprons.

Marker - An object displayed above ground level in order to indicate an obstacle or delineate a boundary.

Marking - A symbol or group of symbols displayed on the surface of the movement area in order to convey aeronautical information.

Movement area - That part of an aerodrome to be used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron(s).

Non-instrument runway - A runway intended for the operation of aircraft using visual approach procedures or an instrument approach procedure to a point beyond which the approach may continue in visual meteorological conditions.

Note: Visual meteorological conditions (VMC) are described in Chapter 3 of Annex 2 — Rules of the Air.

Normal flight zone (NFZ) - Airspace not defined as LFFZ, LCFZ or LSFZ but which must be protected from laser radiation capable of causing biological damage to the eye.

Obstacle - All fixed (whether temporary or permanent) and mobile objects, or parts thereof, that:

a) are located on an area intended for the surface movement of aircraft; or

b) extend above a defined surface intended to protect aircraft in flight; or

c) stand outside those defined surfaces and that have been assessed as being a hazard to air navigation.

Obstacle free zone (OFZ) - The airspace above the inner approach surface, inner transitional surfaces, and baulked landing surface and that portion of the strip bounded by these surfaces, which is not penetrated by any fixed obstacle other than a low-mass and frangibly mounted one required for air navigation purposes.

Orthometric height - Height of a point related to the geoid, generally presented as an MSL elevation.

Outer main gear wheel span (OMGWS) - The distance between the outside edges of the main gear wheels.

Pavement classification number (PCN) - A number expressing the bearing strength of a pavement for unrestricted operations.

Point-in-space (PinS) approach - The point-in-space approach is based on GNSS and is an approach procedure designed for helicopter only. It is aligned with a reference point located to permit subsequent flight manoeuvring or approach and landing using visual manoeuvring in adequate visual conditions to see and avoid obstacles.

Point-in-space (PinS) visual segment - This is the segment of a helicopter PinS approach procedure from the MAPt to the landing location for a PinS “proceed visually” procedure. This visual segment connects the PinS to the landing location.

Note: The procedure design criteria for a PinS approach and the detailed design requirements for a visual segment are established in the Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS, Doc 8168).

Precision approach runway, see Instrument runway.

Protected flight zones - Airspace specifically designated to mitigate the hazardous effects of laser radiation.

Rejected take-off area - A defined area on a heliport suitable for helicopters operating in performance class 1 to complete a rejected take-off.

Road - An established surface route on the movement area meant for the exclusive use of vehicles.

Road-holding position - A designated position at which vehicles may be required to hold.

Runway - A defined rectangular area on a land aerodrome prepared for the landing and take-off of aircraft.

Runway end safety area (RESA) - An area symmetrical about the extended runway centre line and adjacent to the end of the strip primarily intended to reduce the risk of damage to an aeroplane undershooting or overrunning the runway.

Runway guard lights - A light system intended to caution pilots or vehicle drivers that they are about to enter an active runway.

Runway-holding position - A designated position intended to protect a runway, an obstacle limitation surface, or an ILS/MLS critical/sensitive area at which taxiing aircraft and vehicles shall stop and hold, unless otherwise authorized by the aerodrome control tower.

Note: In radiotelephony phraseologies, the expression “holding point” is used to designate the runway-holding position.

Runway strip - A defined area including the runway and stopway, if provided, intended:

(a) to reduce the risk of damage to aircraft running off a runway; and

(b) to protect aircraft flying over it during take-off or landing operations.

Runway turn pad - A defined area on a land aerodrome adjacent to a runway for the purpose of completing a 180-degree turn on a runway.

Runway visual range (RVR) - The range over which the pilot of an aircraft on the centre line of a runway can see the runway surface markings or the lights delineating the runway or identifying its centre line.

Safety management system (SMS) - A systematic approach to managing safety including the necessary organizational structure, accountabilities, policies, and procedures.

Shoulder - An area adjacent to the edge of a pavement so prepared as to provide a transition between the pavement and the adjacent surface.
Sign:

(a) **Fixed message sign** - A sign presenting only one message.

(b) **Variable message sign** - A sign capable of presenting several predetermined messages or no message, as applicable.

Signal area - An area on an aerodrome used for the display of ground signals.

Static load-bearing surface - A surface capable of supporting the mass of a helicopter situated upon it

Station declination - An alignment variation between the zero-degree radial of a VOR and true north, determined at the time the VOR station is calibrated.

Stopway - A defined rectangular area on the ground at the end of take-off run available prepared as a suitable area in which an aircraft can be stopped in the case of an abandoned take-off.

Switch-over time (light) - The time required for the actual intensity of a light measured in each direction to fall from 50 per cent and recover to 50 per cent during a power supply changeover, when the light is being operated at intensities of 25 per cent or above.

Take-off runway - A runway intended for take-off only.

Taxiway - A defined path on a land aerodrome established for the taxiing of aircraft and intended to provide a link between one part of the aerodrome and another, including:

a) **Aircraft stand taxilane** - A portion of an apron designated as a taxiway and intended to provide access to aircraft stands only.

b) **Apron taxiway** - A portion of a taxiway system located on an apron and intended to provide a through taxi-route across the apron.

c) **Rapid exit taxiway** - A taxiway connected to a runway at an acute angle and designed to allow landing aeroplanes to turn off at higher speeds than are achieved on other exit taxiways thereby minimizing runway occupancy times.

Taxiway intersection - A junction of two or more taxiways.

Taxiway strip - An area including a taxiway intended to protect an aircraft operating on the taxiway and to reduce the risk of damage to an aircraft accidentally running off the taxiway.

Threshold - The beginning of that portion of the runway usable for landing.

Touchdown zone - The portion of a runway, beyond the threshold, where it is intended landing aeroplanes first contact the runway.

Usability factor - The percentage of time during which the use of a runway or system of runways is not restricted because of the crosswind component.

Note: Crosswind component means the surface wind component at right angles to the runway centre line.

191.9 Abbreviations

ACN	Aircraft classification number
AMD	Aerodrome mapping data
AMDB	Aerodrome mapping database
ARIWS	Autonomous runway incursion warning system
CG	Centre of gravity
CRC	Cyclic redundancy check
DH	Decision height
FOD	Foreign object debris
LCFZ	Laser-beam critical flight zone
LDA	Landing distance available
LFFZ	Laser-beam free flight zone
LSFZ	Laser-beam sensitive flight zone
MEHT	Minimum eye height over threshold
MSL	Mean sea level
NFZ	Normal flight zone
OCA/H	Obstacle clearance altitude/height
OFZ	Obstacle free zone
OMGWS	Outer main gear wheel span
PCN	Pavement classification number
PinS	Point-in-space
RESA	Runway end safety area
RVR	Runway visual range
SMS	Safety management system
TODA	Take-off distance available
TORA	Take-off run available
WGS-84	World Geodetic System

191.11 Applicability

The requirements of OTAR Part shall apply to all certificated aerodromes or at aerodromes where the Governor requires compliance with this OTAR Part.

191.13 ICAO compliance

(a) Except as set out in sub-paragraphs (b) to (d), the operator of an aerodrome shall comply with:

(1) ICAO Annex 14 and Annex 19 Standards and Recommended Practices; or

(2) where there is a difference between an applicable Standard and Recommended Practice, the more stringent shall be applied; and

(3) this OTAR Part; and

(4) where applicable, OTAR Part 178; and

(5) where the requirements of this OTAR Part are inconsistent with those of paragraph OTAR 191.13(a)(1), the OTAR requirement shall take precedence.

(b) If an aerodrome operator is unable to achieve compliance or wishes to adopt an alternative means of compliance from that specified in paragraph OTAR 191.13(a) it may submit, following consideration through its safety management system, a safety assessment to the Governor in support of its case.

(c) A safety assessment is a study of an aeronautical problem to identify possible solutions and select one that is acceptable without degrading safety. A safety assessment shall:

(1) assess the impact of a proposed deviation from the requirements; and

(2) present alternative means of ensuring the safety of aircraft operations; and

(3) estimate the effectiveness of each alternative and to recommend procedures to compensate for the deviation.

(d) Where ICAO Annex 14 places an obligation on a State, it does not apply to the operator of a certificated aerodrome.

Subpart B – Aerodrome Data

191.19 Aerodrome reference code

(a) For aerodrome planning purposes, the characteristics of the aeroplane for which an aerodrome facility is intended shall be considered when selecting an aerodrome reference code — code number and letter.

(b) The meanings assigned to the aerodrome reference code numbers and letters are listed in Table 1.

(c) The code number for element 1 shall be determined by selecting the code number corresponding to the highest value of the aeroplane reference field lengths of the aeroplanes that the runway is intended for from Table 1.

Note 1: The aeroplane reference field length is determined solely for the purpose of selecting a code number and has no bearing on the actual runway length provided.

Note 2: OTAC 191-1 provides guidance on determining runway length.

(d) The code letter for element 2 shall be determined by selecting the code letter corresponding to the largest wingspan of the aeroplanes for which the facility is intended from Table 1.

Note: OTAC 191-1 provides instructions for determining the aerodrome reference code.

Table 1: Aerodrome reference code

Code element 1	
Code number	**Aeroplane reference field length**
1	Less than 800 m
2	800 m up to but not including 1 200 m
3	1 200 m up to but not including 1 800 m
4	1 800 m and over
Code element 2	
Code letter	**Wingspan**
A	Up to but not including 15 m
B	15 m up to but not including 24 m
C	24 m up to but not including 36 m
D	36 m up to but not including 52 m
E	52 m up to but not including 65 m
F	65 m up to but not including 80 m

Note: Parts 1 and 2 of the Aerodrome Design Manual (Doc 9157) provide planning advice for aeroplanes with wingspans over 80 metres.

191.21 Aeronautical data

(a) The accuracy and integrity classification required to meet the needs of end-users of aeronautical data shall be followed when determining and reporting aerodrome-related aeronautical data.

Note 1: Specifications concerning the accuracy and integrity classification related to aerodrome-related aeronautical data are contained in PANS-AIM (Doc 10066), Appendix 1.

Note 2: Guidance material concerning the application of aerodrome mapping databases is provided in Appendix G of this OTAR.

(b) Aeronautical information services shall have access to aerodrome mapping data.

Note: Aerodrome mapping databases are covered in Annex 15, Chapter 5, and PANS-AIM (Doc 10066), Chapter 5.

(c) Where made available in accordance with OTAR 191.43 (b), the selection of the aerodrome mapping data features to be collected shall be made considering the intended applications.

Note: It is intended that the features collected correspond to a defined operational need.

(d) Digital data error detection techniques shall be used during the transmission and/or storage of aeronautical data and digital data sets.

Note: PANS-AIM (Doc 10066) contains comprehensive specifications for digital data error detection methods.

191.23 Aerodrome reference point

(a) A reference point for an aerodrome shall be established.

(b) The aerodrome reference point shall be established near the aerodrome's initial or planned geometric centre and shall normally remain there.

(c) The position of the aerdrome reference point shall be measured and reported to the authority responsible for aeronautical information services in degrees, minutes, and seconds.

191.25 Aerodrome and runway elevations

(a) The aerodrome elevation and geoid undulation at the aerodrome elevation position shall be measured and reported to the aeronautical information services authority to a precision of one-half metre or foot.

(b) When an aerodrome is used by international civil aviation for non-precision approaches, the elevation and geoid undulation of each threshold, the elevation of the runway end, and any significant high and low intermediate points along the runway shall be measured and reported to the aeronautical information services authority to an accuracy of the one-half metre or foot.

(c) For precision approach runways, the elevation and geoid undulation of the threshold, the elevation of the runway end, and the highest elevation of the touchdown zone shall be measured and reported to the aeronautical information services authority to a precision of one-quarter metre or foot.

Note: Geoid undulation must be measured in accordance with the appropriate system of coordinates.

191.27 Aerodrome reference temperature

(a) An aerodrome reference temperature shall be established in Celsius degrees.

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

191.29 Aerodrome dimensions and related information

(a) For each facility provided on an aerodrome, the following data shall be measured or described as appropriate:

(1) runway — true bearing to one-hundredth of a degree, designation number, length, width, displaced threshold location to the nearest metre or foot, slope, surface type, type of runway and, for a precision approach runway category I, the existence of an obstacle-free zone when provided,

(2) strip
runway end safety area
stopway } length, width to the nearest metre or foot, surface type, and

arresting system — location (which runway end) and description,

(3) arresting system — location (which runway end) and description,

(4) apron — surface type, aircraft stands,

(5) the boundaries of the air traffic control service,

(6) clearway — length to the nearest metre or foot, ground profile,

(7) visual aids for approach procedures, marking and lighting of runways, taxiways and aprons; other visual guidance and control aids on taxiways and aprons, including taxi-holding positions and stopbars, and location and type of visual docking guidance systems,

(8) location and radio frequency of any VOR aerodrome checkpoint,

(9) location and designation of standard taxi routes, and

(10) distances to the nearest metre or foot of localizer and glide path elements comprising an instrument landing system (ILS) or azimuth and elevation antenna of a microwave landing system (MLS) in relation to the associated runway extremities.

(b) The geographical coordinates of each of the threshold shall be measured and reported to the authority responsible for aeronautical information services in degrees, minutes, seconds, and hundredths of seconds.

(c) The geographic coordinates of appropriate taxiway centre line points shall be measured and reported to the aeronautical information services authority in degrees, minutes, seconds, and hundredths of a second.

(d) The geographical coordinates of each of the aircraft stand shall be measured and reported to the aeronautical information services authority in degrees, minutes, seconds, and hundredths of seconds.

(e) The geographical coordinates of obstacles in Areas 2 and 3 shall be measured and reported to the aeronautical information services authority in degrees, minutes, seconds, and tenths of seconds. Furthermore, the top elevation, type, marking, and lighting (if any) of obstacles shall be reported to the authority in charge of aeronautical information services.

Note: PANS-AIM (Doc 10066), Appendix 8, specifies the requirements for determining obstacle data in Areas 2 and 3.

191.31 Strength of pavements

(a) The bearing strength of a pavement intended for aircraft with apron (ramp) masses greater than 5700 kg shallbe made available using the aircraft classification number-pavement classification number (ACN-PCN) method by reporting the following information:

(1) pavement classification number (PCN),

(2) pavement type for ACN-PCN determination,

(3) subgrade strength category,

(4) maximum allowable tire pressure category or maximum allowable tire pressure value, and

(5) evaluation method.

Note: PCNs may be published to an accuracy of one-tenth of a whole number if necessary.

(b) The reported PCN shall indicate that aircraft with an aircraft classification number (ACN) equal to or less than the reported PCN are permitted to operate on the pavement, subject to any tyre pressure or aircraft all-up mass limitations for the specified aircraft type (s).

Note: If the strength of the pavement varies seasonally, different PCNs may be reported.

(c) The ACN of an aircraft shall be determined using the standard procedures associated with the ACN-PCN method.

(d) To determine the ACN, the pavement behaviour shall be classified as equivalent to a rigid or flexible construction.

Note: For further guidance, please refer to OTAC 139-7

(e) The aerodrome shall use the ICAO Annex 14 Volume.1 para 2.6.6 codes to report information on pavement type for ACN-PCN determination, subgrade strength category, maximum allowable tyre pressure category, and evaluation method.

(f) In accordance with 193.99 (a) and(b), criteria shall be established to regulate the use of pavement by an aircraft with an ACN greater than the PCN reported for that pavement.

Note: OTAC 139-7 provides guidance to aerodrome operators on establishing criteria to regulate the use of a pavement by an aircraft with an ACN higher than the PCN reported for that pavement.

(g) The bearing strength of a pavement intended for aircraft with an apron (ramp) mass of 5700 kg or less shall be made available by reporting the following information:

(1) maximum allowable aircraft mass, and

(2) maximum allowable tire pressure.

191.33 Pre-flight altimeter check location

(a) An aerodrome shall have one or more pre-flight altimeter check locations.

(b) A pre-flight check location shall be located on an apron.

Note: Locating a pre-flight altimeter check location on an apron allows for an altimeter check before obtaining taxi clearance, eliminating the need to stop for that purpose after leaving the apron. Normally, an entire apron will suffice as an altimeter check location.

(c) The elevation of a pre-flight altimeter check location shall be given as the average elevation of the area on which it is located, rounded to the nearest metre or foot. The elevation of any portion of a pre-flight altimeter check location shall be within 3 m (10 ft) of the average elevation for that location.

191.35 Declared distances

(a) For a runway intended for international commercial air transport, the following distances shall be calculated to the nearest metre or foot:

(1) take-off run available (TORA),

(2) take-off distance available (TODA),

(3) accelerate-stop distance available (ASDA), and

(4) landing distance available (LDA)

Note: Appendix F of this OTAR details the calculation of declared distances.

191.37 Visual approach slope indicator systems

(a) The following details regarding the installation of a visual approach slope indicator system shall be made available:

(1) associated runway designation number

(2) type of system in accordance with OTAR 191.193 (b). For PAPI, or APAPI installation, left or right side of the runway where the lights are installed shall be specified;

(3) when the axis of the system is not parallel to the runway centerline, the angle of displacement and the direction of the displacement, either left or right, shall be specified;

(4) Approach slope angle, nominal(s). This shall be angle (B + C) ÷ 2 for a PAPI and (A + B) ÷ 2, respectively, as shown in Figure 26; and

(5) MEHT over the on-slope signal threshold(s). In the case of a PAPI, this is the setting angle of the third unit away from the runway, i.e. angle B minus 2', and in the case of an APAPI, this is the setting angle of the unit farther away from the runway, i.e. angle A minus 2'.

Subpart C – Runways

191.41 General information

(a) The number and orientation of runways at an aerodrome shall be such that the usability factor of the aerodrome is not less than 95% for the aircraft that the aerodrome is intended to serve.

Note: OTAC 191-1 provides guidance on the determination of the orientation, siting and number of runways

(b) To avoid future noise problems, the siting and orientation of runways at an aerodrome shall 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.

Note: The Airport Planning Manual (Doc 9184), Part 2 and Guidance on the Balanced Approach to Aircraft Noise Management (Doc 9829) both offer information on how to address noise issues.

(c) In the application of 139.99 (a), it shall be assumed that landing or take-off of aircraft is normally precluded when the crosswind component exceeds:

(1) 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 crosswind component not exceeding 24 km/h (13 kt) shall be assumed,

(2) 4 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

(3) 19 km/h (10 kt) in the case of aeroplanes whose reference field length is less than 1 200 m

(d) The data used to calculate the usability factor shall be based on reliable wind distribution statistics that extend over as long as possible, preferably not less than five years. The observations shall be made at least eight times per day and at equal intervals.

(e) The data used to calculate the usability factor shall be based on reliable wind distribution statistics that extend over as long as possible, preferably not less than five years. The observations shall be made at least eight times per day and at equal intervals.

Note: Instructions on calculating the estimate of the usability factor and any adjustments that may need to be made to account for the impact of unusual circumstances are provided in OTAC 191-1.

191.43 Thresholds

(a) Unless operational considerations justify a different location, a threshold shall normally be located at the end of a runway.

Note: Guidance on the siting of the threshold is provided in OTAC 191-1.

(b) When it is necessary to displace a threshold, either permanently or temporarily, from its normal location, consideration shall be given to the various factors that may influence the location of the threshold. If an unserviceable runway condition causes displacement, a cleared and graded area of at least 60m in length shall be available between the unserviceable area and the displaced threshold. Additional space shall be provided to meet the requirements of the runway end safety area if required.

Note: Guidance on factors that may be considered in determining the location of a displaced threshold is provided in OTAC 191-1.

191.45 Runway length and width

(a) Unless otherwise specified in OTAR 191.45 (b), the actual runway length shall be sufficient to meet the operational needs of the aircraft for which it is intended and shall not be less than the longest length determined after applying the corrections for local conditions to the operations and performance characteristics of the relevant aircraft.

(b) When a runway is associated with a stopway or clearway, an actual runway length less than that resulting from the application of OTAR 191.45 (a) may be considered satisfactory; however, in such a case, any combination of the runway, stopway, and clearway provided shall permit compliance with the operational requirements for take-off and landing of the aeroplanes the runway is intended to serve.

(c) The width of a runway shall not be less than the appropriate dimension specified in the following table:

Table 2: Width of runways

	Outer Main Gear Wheel Span (OMGWS)			
Code number	Up to but not including 4.5 m	4.5 m up to but not including 6 m	6 m up to but not including 9 m	9 m up to but not including 15 m
1[a]	18 m	18 m	23 m	–
2[a]	23 m	23 m	30 m	–
3	30 m	30 m	30 m	45 m
3	–	–	45 m	45 m
[a] Precision approach runway's width shall be less than 30 m where the code number is 1 or 2.				

Note 1: Combinations of code numbers and OMGWS for which widths are defined have been designed based on the characteristics of typical aircraft.

Note 2: The Aerodrome Design Manual (Doc 9157), Part 1, contains information on the factors influencing runway width.

Note 3: Refer to OTAR 191.53 on the supply of runway shoulders, especially for Code F aircraft with four or more engines.

191.47 Runway longitudinal slopes

(a) The slope calculated by dividing the difference between the maximum and minimum elevations along the runway centre line by the length of the runway shall not be greater than:

(1) 1 per cent where the code number is 3 or 4; and,

(2) 2 per cent where the code number is 1 or 2.

(b) The longitudinal slope of a runway shall not exceed the following:

(1) 1.25 per cent where the code number is 4, except that for the first and last quarters of the length of the runway, the longitudinal slope shall not exceed 0.8 per cent,

(2) 1.5 per cent where the code number is 3, except that for the first and last quarter of the length of a precision approach runway category II or III, the longitudinal slope shall not exceed 0.8 per cent, and

(3) 2 per cent where the code number is 1 or 2.

Note: OTAC 191-1 provides instructions on slope changes prior to a runway.

(c) When slope changes are unavoidable, the slope change between two consecutive slopes shall not exceed the following:

(1) 1.5 per cent where the code number is 3 or 4, and

(2) 2 per cent where the code number is 1 or 2.

(d) The transition from one slope to another shall be accomplished by a curved surface with a rate of change not exceeding:

(1) 0.1 per cent per 30 m (minimum radius of curvature of 30 000 m) where the code number is 4,

(2) 0.2 per cent per 30 m (minimum radius of curvature of 15 000 m) where the code number is 3, and

(3) 0.4 per cent per 30 m (minimum radius of curvature of 7 500 m) where the code number is 1 or 2.

(e) Where slope changes are unavoidable, they shall be designed so that there is an unobstructed line of sight from:

(1) any point 3 m above a runway to all other points 3 m above the runway within a distance of at least half the length of the runway where the code letter is C, D, E or F,

(2) any point 2 m above a runway to all other points 2 m above the runway within a distance of at least half the length of the runway where the code letter is B; and

(3) any point 1.5 m above a runway to all other points 1.5 m above the runway within a distance of at least half the length of the runway where the code letter is A.

Note: Where a full-length parallel taxiway is unavailable, consideration must be given to providing an unobstructed line of sight along the entire length of a single runway. Where the runways intersect, additional criteria regarding the line of sight of the intersection area need to be considered for operational safety (see the Aerodrome Design Manual (Doc 9157), Part 1).

(f) Undulations or significant changes in slopes along a runway shall be avoided. The distance between points of intersection of two successive curves shall not be less than:

(1) the sum of the absolute numerical values of the corresponding slope changes multiplied by the appropriate value as follows:

(i) 30 000 m where the code number is 4,

(ii) 15 000 m where the code number is 3, and

(iii) 5 000 m where the code number is 1 or 2, or

(2) 45 m;

whichever is greater.

Note: OTAC 191-1 contains instructions on how to implement this specification.

191.49 Runway transverse slopes

(a) To ensure rapid water drainage, the runway surface shall be cambered whenever possible, except where a single crossfall from high to low in the direction of the wind most frequently associated with rain would suffice. Ideally, the transverse slope shall be:

(1) 1.5 per cent where the code letter is C, D, E or F, and

(2) 2 per cent where the code letter is A or B;

but shall not exceed 1.5 or 2%, as applicable, nor shall it be less than 1%, except at runway or taxiway intersections where flatter slopes may be required.

(b) The transverse slope on each side of the centre line shall be symmetrical for a cambered surface.

Note: On wet runways with crosswinds, the problem of aquaplaning from poor drainage is likely to increase. Parts 1 and 3 of the Aerodrome Design Manual (Doc 9157) contain additional information.

(c) The transverse slope of a runway shall be substantially constant throughout its length, except at intersections with other runways or taxiways, where an even transition shall be provided to allow for adequate drainage.

Note: The Aerodrome Design Manual (Doc 9157), Part 2 provides guidance on the transverse slope.

191.51 Surface and strength of runways

(a) A runway shall be able to withstand the amount of aircraft traffic it is intended to serve.

(b) A surface of the runway shall be free of irregularities impairing the runway friction characteristics or adversely affecting take-off or landing of an aeroplane.

Note 1: Surface irregularities can impede take-off or landing of an aeroplane by causing excessive bouncing, pitching, vibration, or other control difficulties.

Note 2: Attachment A, Section 5, provides instructions on design tolerances and other information. Part 3 of the Aerodrome Design Manual (Doc 9157) provides additional instructions.

(c) A paved runway shall be constructed or resurfaced in such a way that the surface friction characteristics of the runway are equal to or greater than the minimum friction level.

Note: Additional guidance is provided in the Airport Services Manual (Doc 9137), Part 2.

(d) When constructing or resurfacing a paved runway, the surface friction characteristics shall be evaluated to ensure that they meet the design objectives.

(e) Surface friction characteristics of a newly constructed or resurfaced paved runway shall be determined using a continuous friction measuring device equipped with self-wetting features.

(f) The average surface texture depth of a new surface shall not be less than 1.0 m.

Note 1: Macrotexture and microtexture are considered to provide the required surface friction characteristics.

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

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

(g) When grooving or scoring the surface, the grooves or scorings shall be parallel to the runway centre line or parallel to non-perpendicular transverse joints, as applicable.

Note: Guidance on improving the runway surface texture is given in the Aerodrome Design Manual (Doc 9157), Part 3.

191.53 Runway shoulders

(a) Runway shoulders shall be provided for a runway where the code letter is D, E or F.

(b) For aircraft with an OMGWS from 9 up to but not icluding 15 metres, the runway shoulders shall extend symmetrically on each side of the runway, ensuring that the total width of the runway and its shoulders do not fall below:

(1) 60 m where the code letter is D or E,

(2) 60 m where the code letter is F with two- or three-engined aeroplanes; and

(3) 75 m where the code letter is F with four (or more)-engined aeroplanes.

(c) The surface of the shoulder that abuts the runway shall be flush with the surface of the runway, and its transverse slope shall not exceed 2.5 per cent.

(d) The portion of a runway shoulder between the runway edge and 30 m from the runway centre line shall be prepared or constructed in such a way that, in the event of an aeroplane running off the runway, it can support the aeroplane without causing structural damage to the aeroplane, as well as ground vehicles that may operate on the shoulder.

Note: Guidance on improving the runway surface texture is provided in the Aerodrome Design Manual (Doc 9157), Part 3.

(e) A runway shoulder shall be prepared or constructed to resist erosion and material ingestion by aircraft engines.

(f) Runway shoulders shall be paved to a minimum overall width of the runway and shoulder of not less than 60 metres for code letter F aircraft.

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

191.55 Runway turn pads

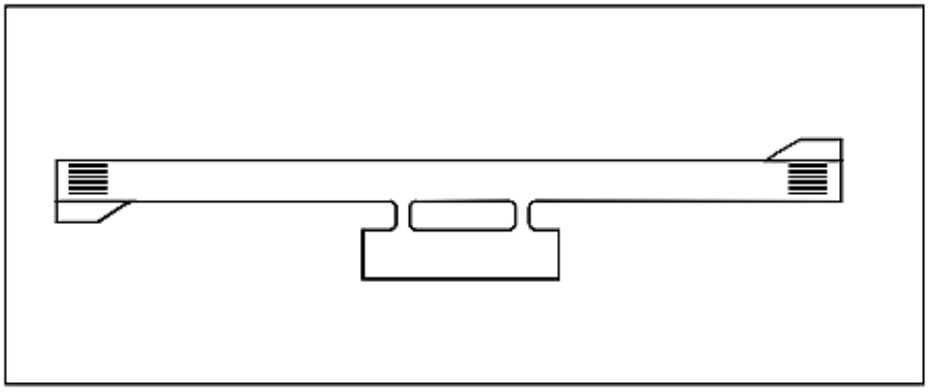
(a) Where a runway end is not served by a taxiway or a taxiway turnaround and the code letter is D, E, or F, a runway turn pad shall be provided to enable aeroplanes to make a 180-degree turn (see Figure 1).

(b) Where a runway end is not served by a taxiway or a taxiway turnaround and the code letter is A, B, or C, a runway turn pad shall be provided to enable aeroplanes to make a 180-degree turn.

Note 1: These areas may also be beneficial if they are provided along a runway to reduce taxiing time and distance for aircraft that do not require the entire runway.

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

Figure 1: The example of a turn pad layout.



Source: ICAO Annex 14 Volume 1

(c) The runway turn pad may be located on either the left or right side of the runway, adjacent to the runway pavement at both ends of the runway and selected intermediate locations.

Note: Ideally, the turn pad should be located on the left side of the runway, as the left seat is the normal position for the pilot-in-command.

(d) The angle of the runway turn pad intersection with the runway shall not exceed 30 degrees.

(e) When designing the runway turn pad, the nose wheel steering angle shall not be greater than 45 degrees.

(f) A runway turn pad shall be designed in such a way that when the cockpit of the aircraft for which the turn pad is intended remains above the turn pad marking, the clearance distance between any wheel of the aircraft's landing gear and the edge of the turn pad shall not be less than that specified in the following table:

Table 3: Clearance distances for turn pads

	OMGWS			
	Up to but not including 4.5 m	4.5 m up to but not including 6 m	6 m up to but not including 9 m	9 m up to but not including 15 m
Clearance	1.50 m	2.25 m	3 m[a] or 4 m[b]	4 m

[a] If the turn pad is intended to be used by aeroplanes with a wheelbase less than 18 m.
[b] If the turn pad is intended to be used by aeroplanes with a wheelbase equal to or greater than 18 m.

Note: Wheelbase means the distance from the nose gear to the geometric centre of the main gear.

(g) The longitudinal and transverse slopes of the runway turn-pad shall be sufficient to prevent water from accumulating on the surface and allow for rapid surface water drainage. The slopes shall be the same as those on the adjacent runway pavement surface.

(h) The strength of a runway turn pad shall be at least equal to that of the adjacent runway it serves, considering that the turn pad will be subjected to slow-moving traffic making hard turns, resulting in increased stresses on the pavement.

Note: Where a flexible pavement surface is used to cover a runway turn pad, the surface must withstand the horizontal shear forces exerted by the main landing gear tyres during turning manoeuvres.

(i) The surface of a runway turn pad shall be free of surface irregularities that could cause damage to an aircraft using the turn pad.

(j) The surface of a runway turn pad shall be constructed or resurfaced in such a way that it has surface friction characteristics that are at least equal to those of the adjacent runway.

(k) Shoulders of sufficient width shall be provided on the runway turn pads to prevent surface erosion by the jet blast of the most demanding aeroplane for which the turn pad is intended, as well as any potential foreign object damage to the aeroplane engines.

Note: The width of the shoulders would have to be at least as wide as the outer engine of the most demanding aircraft and thus could be wider than the associated runway shoulders.

(l) The strength of runway turn pad shoulders shall be sufficient to withstand the occasional passage of the aircraft it is designed to serve without causing structural damage to the aircraft or any supporting ground vehicles that may operate on the shoulder.

191.57 Runway strips

(a) A strip shall include a runway and any associated stopways.

(b) A strip shall extend for at least the following distance before the threshold and beyond the end of the runway or stopway:

(1) 60 m where the code number is 2, 3 or 4,

(2) 60 m where the code number is 1 and the runway is an instrument one, and

(3) 30 m where the code number is 1 and the runway is non-instrument.

(c) Wherever possible, a strip with a precision approach runway shall extend laterally to a distance of at least:

(1) 140 m where the code number is 3 or 4, and

(2) 70 m where the code number is 1 or 2

on each side of the runway centre line and its extended centre line throughout the length of the strip.

(d) A strip with a non-precision approach runway shall extend laterally for at least:

(1) 140 m where the code number is 3 or 4, and

(2) 70 m where the code number is 1 or 2;

on each side of the runway centre line and its extended centre line throughout the length of the strip.

(e) A strip with a non-instrument runway shall extend on each side of the runway centre line and its extended centre line the length of the strip to a distance of at least:

(1) 75 m where the code number is 3 or 4,

(2) 40 m where the code number is 2, and

(3) 30 m, where the code number is 1.

(f) An object on a runway strip that may endanger aircraft shall be considered an obstacle and, as far as practicable, removed.

Note 1: Refer to Subpart Q for details on equipment and installation placement on runway strips.

Note 2: The location and design of drains on a runway strip must be considered to prevent damage to an aircraft that runs off the runway accidentally.

Note 3: When installing open-air or covered storm water conveyances, care must be taken to ensure that their structure does not extend above the surrounding ground and is not considered an obstacle. For further guidance, see the Aerodrome Design Manual (Doc 9157), Part 1

Note 4: To prevent wildlife attraction, particularly bird attraction, special care must be taken in designing and maintaining an open-air storm water conveyance. A net can be used to cover it if necessary. Procedures on wildlife management are specified in the PANS-Aerodromes (Doc 9981) and OTAC 191-1. Further guidance can be found in the Airport Services Manual (Doc 9137), Part 3

(g) No fixed object shall be permitted on any part of a precision approach runway delineated by the lower edges of the inner transitional surfaces other than visual aids required for air navigation or those required for aircraft safety purposes, and which shall be sited on the runway strip and satisfy the relevant frangibility requirement. During the use of the runway for landing or take-off, no mobile object shall be permitted on this section of the runway strip.

Note See OTAR 191.119 (f) for characteristics of inner transitional surfaces.

(h) That portion of an instrument runway strip within a distance of at least:

(1) 75 m where the code number is 3 or 4, and

(2) 40 m where the code number is 1 or 2;

of the runway centre line and its extended centre line shall provide a graded area for aeroplanes that the runway is intended to serve in the event of an aeroplane running off the runway.

Note: OTAC 191-1 provides instructions on grading a greater portion of a strip, including a precision approach runway, when the code number is 3 or 4.

(i) That portion of an instrument runway strip within a distance of at least:

(1) 75 m where the code number is 3 or 4;

(2) 40 m where the code number is 2, and

(3) 30 m where the code number is 1

of the runway centre line and its extended centre line shall provide a graded area for aeroplanes that the runway is intended to serve in the event of an aeroplane running off the runway.

(j) The surface of a strip adjacent to a runway, shoulder, or stopway shall be flush with the surface of the runway, shoulder, or stopway.

(k) To protect a landing aircraft from the dangers of an exposed edge, the portion of a strip up to at least 30 m before the start of a runway shall be prepared against blast erosion.

Note 1: The area provided to reduce the erosive effects of jet blast and propeller wash may be referred to as a blast pad.

Note 2: Guidance on protection against aeroplane engine blasts is provided in the Aerodrome Design Manual (Doc 9157), Part 2.

(l) Where the areas mentioned in OTAR 191.95 (c) have paved surfaces, they shall withstand the occasional passage of the critical aeroplane for runway pavement design.

(m) A longitudinal slope along the graded portion of a strip shall not be greater than:

(1) 1.5 per cent where the code number is 4,

(2) 1.75 per cent where the code number is 3, and

(3) 2 per cent where the code number is 1 or 2.

(n) Slope changes on the graded portion of a strip shall be as gradual as possible, with abrupt changes or reversals of slopes avoided.

(o) Transverse slopes on the graded portion of a strip shall be sufficient to prevent water accumulation on the surface but shall not exceed the following:

(1) 2.5 per cent where the code number is 3 or 4, and

(2) 3 per cent where the code number is 1 or 2;

except that the slope for the first 3 m outward from the runway, shoulder, or stopway edge shall be negative as measured away from the runway and may be as high as 5 per cent to facilitate drainage.

(p) The transverse slopes of any portion of a strip other than that to be graded shall not exceed a 5 per cent upward slope measured away from the runway.

Note 1: Where necessary for proper drainage, an open-air storm water conveyance may be permitted in the non-graded portion of a runway strip and would be located as far away from the runway as possible.

Note 2: The location of open-air water conveyances within the non-graded portion of a runway strip would have to be considered in the aerodrome Rescue and Firefighting (RFF) procedure.

(q) That portion of a strip of an instrument runway within a distance of at least:

(1) 75 m where the code number is 3 or 4, and

(2) 40 m where the code number is 1 or 2;

from the centre line of the runway and its extended centre line shall be so prepared or constructed as to minimise hazards arising from differences in the load-bearing capacity to aeroplanes which the runway is intended to serve in the event of an aeroplane running off the runway

(r) That portion of a strip containing a non-instrument runway within at least:

(1) 75 m where the code number is 3 or 4,

(2) 40 m where the code number is 2, and

(3) 30 m where the code number is 1;

from the centre line of the runway and its extended centre line shall be so prepared or constructed as to minimise hazards arising from differences in the load-bearing capacity to aeroplanes which the runway is intended to serve in the event of an aeroplane running off the runway

191.59 Runway end safety areas (RESA)

(a) RESA shall be provided at each end of a runway strip, where:

(1) the code number is 3 or 4; and

(2) the code number is 1 or 2, and the runway is an instrument one.

(b) RESA shall be provided at each end of a runway strip with a code number of 1 or 2 and a non-instrument runway,.

(c) RESA shall extend at least 90 m from the end of a runway strip where:

(1) the code number is 3 or 4; and

(2) the code number is 1 or 2, and the runway is an instrument one.

If an arresting system is installed, the above length may be reduced based on the system's design specifications, subject to the Governor's approval.

Note: Guidance on arresting systems is given in OTAC 191-1.

(d) RESA shall, as far as practicable, extend from the end of a runway strip to a distance of at least:

(1) 240 m where the code number is 3 or 4, or a reduced length when an arresting system is installed,

(2) 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

(3) 30 m where the code number is 1 or 2 and the runway is a non-instrument one.

(e) RESA shall be at least twice the width of the associated runway.

(f) Wherever possible, the width of RESA shall be equal to the width of the graded portion of the associated runway strip.

(g) An object located on RESA that may endanger aeroplanes shall be considered an obstacle and, as far as practicable, removed.

Note: For details on the placement of installations and equipment on RESA, see OTAR 191.321

(h) In the event of an aeroplane undershooting or overrunning the runway, RESA shall provide a cleared and graded area for the planes that the runway is intended to serve.

Note: It should be noted that the ground surface in the RESA does not need to be prepared to the same standard as the runway strip; however, see OTAR 191.59 (l) for further details.

(i) Slopes of RESA shall be designed so that no part of the runway end safety area penetrates the approach or take-off climb surface.

(j) The longitudinal slopes of the RESA shall not exceed a 5 per cent downward slope. Longitudinal slope changes shall be as gradual as possible, with abrupt changes or reversals avoided.

(k) The transverse slopes of the RESA shall not exceed a 5 per cent upward or downward slope. Transitions between slopes shall be as gradual as practicable.

(l) RESA shall be prepared or built to reduce the risk of an aircraft undershooting or overrunning the runway, to improve aeroplane deceleration, and to facilitate the movement of rescue and firefighting vehicles, as specified in OTAR 140.

191.61 Clearways

(a) The origin of a clearway shall be at the end of the available take-off run.

(b) The length of a clearway shall not be more than half the length of the available take-off run.

(c) A clearway shall extend laterally on each side of the extended centre line of the runway for at least:

(1) 75 m for instrument runways; and

(2) half of the width of the runway strip for non-instrument runways.

(d) The ground in a clearway shall not protrude above a plane with an upward slope of 1.25 per cent, the lower limit of which is a horizontal line that:

(1) is perpendicular to the vertical plane containing the runway centre line; and

(2) passes through a point located on the runway centre line at the end of the take-off run available.

Note: Due to transverse or longitudinal slopes on a runway, shoulder, or strip, the lower limit of the clearway plane specified above may be lower than the corresponding elevation of the runway, shoulder, or strip in some cases. It is not intended that these surfaces be graded to conform to the lower limit of the clearway plane, nor that terrain or objects above the clearway plane beyond the end of the strip but below the level of the strip be removed unless it is determined that they may endanger aeroplanes.

(e) When the slope on the ground in a clearway is relatively small, or the mean slope is upward, abrupt upward changes in slope shall be avoided. In such cases, the slopes, slope changes, and transition from runway to clearway shall generally conform to those of the runway with which the clearway is associated within a distance of 22.5 m or half the runway width, whichever is greater, on each side of the extended centre line.

(f) An object located on a clearway that may endanger aeroplanes in the air shall be considered an obstacle and removed.

Note: The inclusion of detailed specifications for clearways in this section is not intended to imply that a clearway has to be provided. OTAC 191-1 provides information on the use of clearways.

191.63 Stopways

(a) A stopway shall have the same width as the runway with which it is associated.

(b) Slopes and changes in slope on a stopway, as well as the transition from a runway to a stopway, shall comply with the specifications of OTAR 191.57, 191.59, 191.61, 191.63 and 191.65 for the runway with which the stopway is associated, except that:

(1) the limitation in OTAR 191.57 (b) of a 0.8 per cent slope for the first and last quarter of a runway does not apply to the stopway; and

(2) at the junction of the stopway and runway and along the stopway, the maximum rate of slope change may be 0.3 per cent per 30 m (minimum radius of curvature of 10 000 m) for a runway where the code number is 3 or 4.

(c) A stopway shall be prepared or built so that, in the event of an aborted take-off, it can support the aircraft that it is intended to serve without causing structural damage to the aircraft.

Note: OTAC 191-1 provides guidance relative to the support capability of a stopway

(d) The surface of a paved stopway shall be constructed or resurfaced so that it provides surface friction characteristics equal to or greater than those of the associated runway.

Note: The inclusion of detailed specifications for stopways in this section does not imply that a stopway has to be provided. OTAC 191-1 provides information on the use of stopways.

191.65 Radio altimeter operating area

(a) A radio altimeter operating area shall be established in the pre-threshold area of a precision approach runway.

(b) A radio altimeter operating area shall extend at least 300 metres before the threshold.

(c) A radio altimeter operating area shall extend laterally, on each side of the extended runway centre line, to a distance of 60 m unless special circumstances warrant a distance of no less than 30 m if an aeronautical study indicates that such a reduction would not affect the safety of aircraft operations.

(d) Slope changes shall be avoided or kept to a minimum in a radio altimeter operating area. Where slope changes are unavoidable, they shall be as gradual as possible, with no abrupt changes or reversals of slopes. The rate of change between two successive slopes shall not be more than 2 per cent per 30 m.

Note: Guidance on radio altimeter operating areas is provided in OTAC 191-1 and the Manual of All-Weather Operations (Doc 9365), Section 5.2. Guidance on using a radio altimeter is given in the PANS-OPS, Volume II, Part II, Section 1.

Subpart D – Taxiways[1]

191.71 General information

(a) Taxiways shall be provided to ensure safe and efficient movement of aircraft on the ground.

Note: Guidance on the layout and standardised nomenclature of taxiways is given in the Aerodrome Design Manual (Doc 9157), Part 2.

(b) Sufficient entrance and exit taxiways shall be provided for a runway to expedite aircraft movement to and from the runway. Rapid exit taxiways shall be considered when traffic volumes are high.

(c) A taxiway shall be designed in such a way that when the cockpit of the aircraft for which the taxiway is intended remains above the taxiway centre line markings, the clearance distance between the aircraft's outer main wheel and the taxiway edge shall not be less than that specified in the following table:

Table 4: Clearance distances between OMGWS and taxiway edge

	OMGWS			
	Up to but not including 4.5 m	4.5 m up to but not including 6 m	6 m up to but not including 9 m	9 m up to but not including 15 m
Clearance	1.50 m	2.25 m	3 m[a,b] or 4 m[c]	4 m

[a.] On straight portions.
[b.] On curved portions, if the taxiway is intended to be used by aeroplanes with a wheelbase of less than 18 m.
[c.] On curved portions, if the taxiway is intended to be used by aeroplanes with a wheelbase equal to or greater than 18 m.

Note: The term wheelbase refers to the distance between the nose gear and the main geometric centre of the main gear.

Note: OTAC 191-1 provides specific taxiway design guidance that may help prevent runway incursions when developing a new taxiway or improving existing ones with known runway incursion safety risks.

[1] The requirements in this section apply to all types of taxiways unless otherwise stated.

191.73 Dimensions of taxiways

(a) A straight section of a taxiway shall not be less than the width specified in the following table:

Table 5: Width of taxiways

	OMGWS			
	Up to but not including 4.5 m	4.5 m up to but not including 6 m	6 m up to but not including 9 m	9 m up to but not including 15 m
Taxiway width	7.5 m	10.5 m	15 m	23 m

Note: Guidance on the width of taxiways is given in the Aerodrome Design Manual (Doc 9157), Part 2

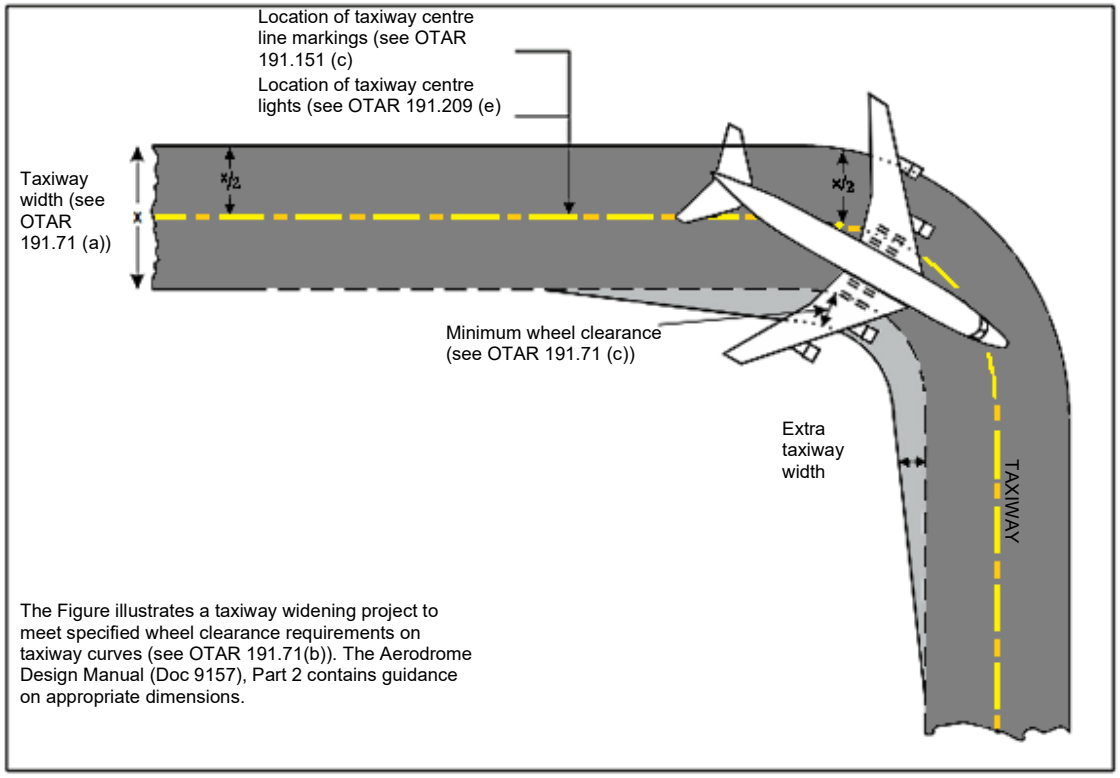
(b) Taxiway direction changes shall be kept to a minimum. The radius of the curves shall be compatible with the manoeuvrability and normal taxiing speeds of the aircraft intended to use the taxiway. The curve shall be designed so that when the cockpit of the aircraft remains above the taxiway centre line markings, the clearance distance between the outer main wheels of the aeroplane and the taxiway edge shall not be less than those specified in OTAR 191.139 (c).

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

Note 2: The location of taxiway centre line markings and lights is specified in OTAR 191.151 (c) and OTAR 191.223 (m).

Note 3: Compound curves may reduce or eliminate the need for extra taxiway width.

Figure 2: Taxiway curve



(c) Fillets shall be provided at the junctions and intersections of taxiways with runways, aprons, and other taxiways to facilitate aircraft movement. When aeroplanes are manoeuvring through junctions or intersections, the design of the fillets shall ensure that the minimum wheel clearances specified in OTAR 191.145 (c) are maintained.

Note: When designing fillets, consideration must be given to the datum length of the aircraft. Guidance on the design of fillets and the definition of the term aeroplane datum length is provided in the Aerodrome Design Manual (Doc 9157), Part 2.

(d) The separation distance between the taxiwaycentre line and the runway centre line, the parallel taxiway centre line, or an object shall not be less than the appropriate dimension specified in Table 6, except that it may be permissible to operate with lower separation distances at an existing aerodrome if an aeronautical study indicates that such lower separation distances would not adversely affect the safety or regularity of operations.

Note 1: Guidance on factors which may be considered in the aeronautical study is provided in the Aerodrome Design Manual (Doc 9157), Part 2.

Note 2: ILS and MLS installations may also affect the location of taxiways due to ILS and MLS signal interference caused by a taxiing or stopped aircraft. Information on critical and sensitive areas surrounding ILS and MLS installations is contained in Annex 10 — Aeronautical Telecommunications, Volume I — Radio Navigation Aids, Attachments C and G (respectively).

Note 3: The separation distances specified in Table 6 do not always permit a normal turn from one parallel taxiway to another. Guidance for this condition is provided in the Aerodrome Design Manual (Doc 9157), Part 2.

Note 4: When the jet exhaust wake velocity may create hazardous conditions for ground service, the separation distance between the centre line of an aircraft stand taxilane and an object, shown in Table 6, may need to be increased.

Table 6: Taxiway minimum separation distances

	Distance between taxiway centre line and runway centre line (metres)								Taxiway centre line to taxiway centre line (metres)	Taxiway, other than aircraft stand taxilane, centre line to object (metres)	Aircraft stand taxilane centre line to aircraft stand taxilane centre line (metres)	Aircraft stand taxilane centre line to object (metres)
	Instrument runways Code number				Non-instrument runways Code number							
Code letter	1	2	3	4	1	2	3	4				
A	77.5	77.5	–	–	37.5	47.5	–	–	23	15.5	19.5	12
B	82	82	152	–	42	52	87	–	32	20	28.5	16.5
C	88	88	158	158	48	58	93	93	44	26	40.5	22.5
D	–	–	166	166	–	–	101	101	63	37	59.5	33.5
E	–	–	172.5	172.5	–	–	107.5	107.5	76	43.5	72.5	40
F	–	–	180	180	–	–	115	115	91	51	87.5	47.5

Note 1: The separation distances shown in the above columns represent typical combinations of runways and taxiways. The basis for developing these distances is in the Aerodrome Design Manual (Doc 9157), Part 2.

Note 2: The distances specified in the above columns do not guarantee sufficient clearance behind a holding aircraft to allow another aircraft to pass on a parallel taxiway. See the Aerodrome Design Manual (Doc 9157), Part 2.

191.75 Taxiway longitudinal slopes

(a) The longitudinal slope of a taxiway shall not exceed the following:

(1) 1.5 per cent where the code letter is C, D, E or F, and

(2) 3 per cent where the code letter is A or B

(b) Where slope changes on a taxiway are unavoidable, the transition between slopes shall be accomplished by a curved surface with a rate of change not exceeding:

(1) 1 per cent per 30 m (minimum radius of curvature of 3 000 m) where the code letter is C, D, E or F; and

(2) 1 per cent per 25 m (minimum radius of curvature of 2 500 m) where the code letter is A or B.

(c) Where it is impossible to avoid a change in slope on a taxiway, the change shall be such that, from any point:

(1) 3 m above the taxiway, it will be possible to see the whole surface of the taxiway for a distance of at least 300 m from that point, where the code letter is C, D, E or F,

(2) 2 m above the taxiway, it will be possible to see the whole surface of the taxiway for a distance of at least 200 m from that point, where the code letter is B; and

(3) 1.5 m above the taxiway, it will be possible to see the whole surface of the taxiway for a distance of at least 150 m from that point, where the code letter is A.

191.77 Taxiway transverse slopes

(a) The transverse slopes of a taxiway shall be sufficient to prevent water accumulation on the surface of the taxiway but shall not exceed the following:

(1) 1.5 per cent where the code letter is C, D, E or F, and

(2) 2 per cent where the code letter is A or B.

191.79 Strength and surface of taxiways

(a) The strength of a taxiway shall be at least equal to that of the runway it serves, with due consideration given to the fact that a taxiway will be subjected to a higher density of traffic and, as a result of slow moving and stationary aeroplanes, higher stresses than the runway it serves.

Note: Guidance on the relation of the strength of taxiways to the strength of runways is provided in the Aerodrome Design Manual (Doc 9157), Part 3.

(b) The surface of a taxiway shall be smooth and free of irregularities that could damage aircraft structures.

(c) The surface of a paved taxiway shall be built or resurfaced to provide adequate surface friction characteristics.

Note: Appropriate surface friction characteristics are those required on taxiways to ensure the safe operation of aeroplanes.

191.81 Rapid exit taxiways (RET)

(a) A RET shall have a turn-off curve radius of at least:

(1) 550 m where the code number is 3 or 4, and

(2) 275 m where the code number is 1 or 2;

to allow for wet-weather exit speeds of:

(i) 93 km/h where the code number is 3 or 4, and

(ii) 65 km/h where the code number is 1 or 2.

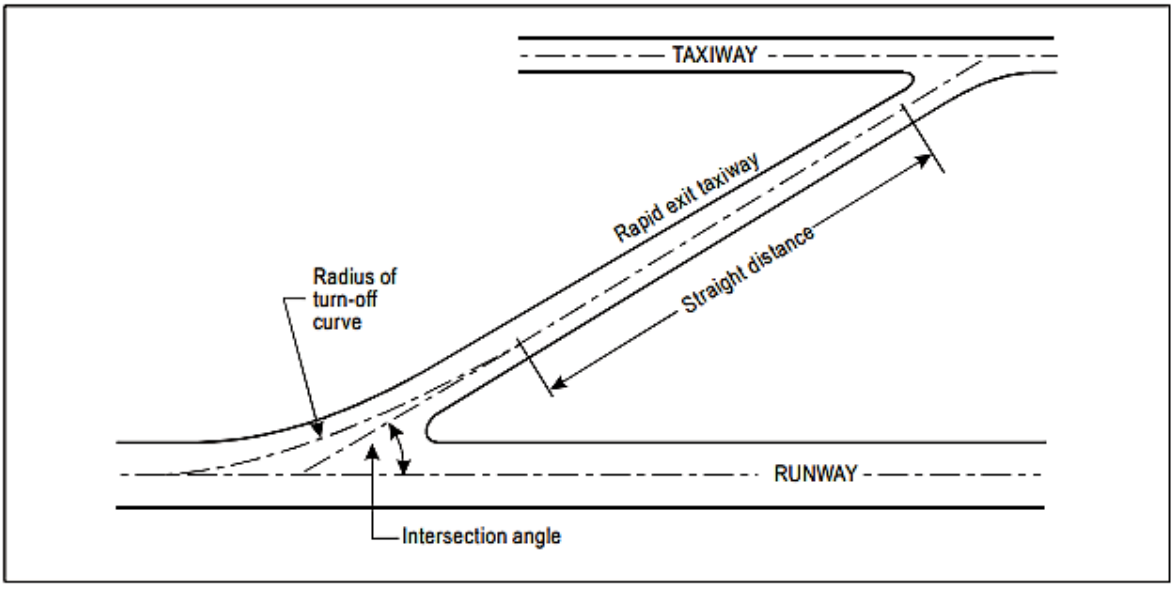
(b) The radius of the fillet on the inside of the curve at a RET shall be large enough to provide a widened taxiway throat, allowing for early recognition of the entrance and turn-off onto the taxiway.

(c) A RET shall have a straight distance after the turn-off curve, allowing an exiting aircraft to come to a complete stop clear of any intersecting taxiway.

(d) An angle ofintersection of a RET with the runway shall not be greater than 45°, nor less than 25°, and shall preferably be 30°.

Note: General requirements for taxiways also apply to this type of taxiway. Guidance on the provision, location and design of RET is included in the Aerodrome Design Manual (Doc 9157), Part 2

Figure 3: Rapid exit taxiway



Source: ICAO Annex 14 Volume 1

191.83 Taxiways on bridges

(a) The width of a taxiway bridge capable of supporting aeroplanes, measured perpendicular to the taxiway centre line, shall not be less than the width of the graded area of the strip provided for that taxiway unless a proven method of lateral restraint is provided that is not hazardous to the aeroplanes for which the taxiway is intended.

(b) Access shall be provided so rescue and firefighting vehicles can intervene in both directions within the specified response time to the largest aircraft for which the taxiway bridge is intended.

Note: If aircraft engines overhang the bridge structure, adjacent areas below the bridge may need to be protected from engine blasts.

(c) A bridge shall be built on a straight section of the taxiway, with a straight section on both ends to help planes align as they approach the bridge.

191.85 Taxiway shoulders

(a) Straight sections of a taxiway with the code letter C, D, E, or F shall have shoulders that extend symmetrically on each side of the taxiway so that the overall width of the taxiway and its shoulders on straight sections does not fall below:

(1) 44 m where the code letter is F;

(2) 38 m where the code letter is E;

(3) 34 m where the code letter is D, and

(4) 25 m where the code letter is C.

The shoulder width on taxiway curves, junctions, and intersections with increased pavement shall not be less than that on the adjacent straight sections of the taxiway.

(b) When a taxiway is intended to be used by turbine-powered aircraft, the surface of the taxiway shoulder shall be prepared to withstand erosion and material ingestion by aircraft engines.

191.87 Taxiway strips

(a) A strip shall include a taxiway other than an aircraft stand taxilane.

(b) A taxiway strip shall extend symmetrically on each side of the taxiway centre line for the entire length of the taxiway or at least the distance specified in Table 6.

(c) The taxiway strip shall be clear of objects that could endanger taxiing aircraft.

Note 1: Refer to Subpart Q for details regarding equipment and installation placement on taxiway strips.

Note 2: Consideration will need to be given to the location and design of drains on a taxiway strip to avoid damage to an aircraft that accidentally runs off the taxiway. Drain covers of appropriate design may be required.

Note 3: When installing open-air or covered storm water conveyances, care must be taken to ensure that their structure does not extend above the surrounding ground, as this would be considered an obstruction. See also Note 1 to OTAR 191.87 (f).

Note 4: A special emphasis should be placed on designing and maintaining an open-air storm water conveyance to avoid attracting wildlife, particularly birds. It can be covered with a net if necessary. Guidance on wildlife control and reduction can be found in the Airport Services Manual (Doc 9137), Part 3 and OTAC 191-1.

(d) The central portion of a taxiway strip shall have a graded area at a distance from the taxiway centre line equal to or greater than that specified below:

(1) 10.25 m, where the OMGWS is up to but not including 4.5 m,

(2) 11 m, where the OMGWS is 4.5 m up to but not including 6 m,

(3) 12.50 m, where the OMGWS is 6 m up to but not including 9 m,

(4) 18.50 m, where the OMGWS is 9 m up to but not including 15 m, where the code letter is D,

(5) 19 m, where the OMGWS is 9 m up to but not including 15 m, where the code letter is E,

(6) 22 m, where the OMGWS is 9 m up to but not including 15 m, where the code letter is F.

(e) The surface of a strip shall be flush with the edge of taxiway or shoulder if provided, and the graded portion shall not have an upward transverse slope greater than:

(1) 2.5 per cent for strips where the code letter is C, D, E or F, and

(2) 3 per cent for strips of taxiways where the code letter is A or B;

the upward slope is determined in relation to the adjacent taxiway transverse slope, not the horizontal slope. The downward transverse slope shall not exceed 5 per cent when measured with reference to the horizontal.

(f) Transverse slopes on any portion of a taxiway strip other than that to be graded shall not exceed 5 per cent in either direction away from the taxiway.

Note 1: Where an open-air storm water conveyance is deemed necessary for proper drainage, it may be permitted in the ungraded portion of a taxiway strip and would be located as far away from the taxiway as possible.

Note 2: Aerodrome RFF procedures need to consider the location of open-air storm water conveyances within the ungraded portion of a taxiway strip.

Note 3: Further guidance on the characteristics of taxiway strips is provided in the Aerodrome Design Manual (Doc 9157), Part 2.

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

(a) Holding bay(s) shall be provided when the Aerodrome Certificate Holder considers traffic density as medium or heavy.

(b) A runway-holding position or positions shall be established:

(1) on the taxiway, at the intersection of a taxiway and a runway, and

(2) when the former runway is part of a standard taxi-route at the intersection of a runway with another runway.

(c) A runway-holding position shall be established if a taxiing aircraft or vehicle can interfere with an obstacle limitation surface or the operation of radio navigation aids due to the location or alignment of the taxiway.

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

(e) A road-holding position shall be established at an intersection of a road with a runway.

(f) The distance between a holding bay, runway-holding position established at a taxiway/runway intersection or road-holding position and the centre line of a runway shall be in accordance with Table 7 and, in the case of a precision approach runway, such that a holding aircraft or vehicle will not interfere with the operation of radio navigation aids or penetrate the inner transitional surface.

Note: Guidance for positioning runway-holding positions is provided in the Aerodrome Design Manual (Doc 9157), Part 2.

(g) The distance of 90 m specified in Table 7 for a precision approach runway code number 4 shall be increased as follows at elevations greater than 700 m (2 300 ft):

(1) up to an elevation of 2 000 m (6 600 ft); 1 m for every 100 m (330 ft) in excess of 700 m (2 300 ft),

(2) elevation in excess of 2 000 m (6 600 ft) and up to 4 000 m (13 320 ft); 13 m plus 1.5 m for every 100 m (330 ft) in excess of 2 000 m (6 600 ft); and

(3) elevation in excess of 4 000 m (13 320 ft) and up to 5 000 m (16 650 ft); 43 m plus 2 m for every 100 m (330 ft) in excess of 4 000 m (13 320 ft).

(h) If a holding bay, runway-holding position, or road-holding position for a precision approach runway code 4 is elevated above the threshold, the distance specified in Table 7 shall be increased by 5 metres for each metre the bay or position is elevated above the threshold.

(i) The location of a runway-holding position established in accordance with OTAR 191.89 (h) shall be such that it does not infringe the obstacle-free zone, approach surface, take-off climb surface, or ILS/MLS critical/sensitive area, or interfere witht the operation of radio navigation aids.

Table 7: Minimum distance from the runway centre line to a holding bay, runway-holding position or road-holding position

	Code number			
Type of runway	1	2	3	4
Non-instrument	30 m	40 m	75 m	75 m
Non-precision approach	40 m	40 m	75 m	75 m
Precision approach category I	60 m[b]	60 m[b]	90 m[a,b]	90 m[a,b]
Precision approach categories II and III	—	—	90 m[a,b]	90 m[a,b]
Take-off runway	30 m	40 m	75 m	75 m

[a] If a holding bay, runway-holding position, or road-holding position is lower than the threshold, the distance may be reduced by 5 m for every metre the bay or holding position is lower than the threshold, provided the inner transitional surface is not infringed upon.

[b] To avoid interference with radio navigation aids, such as the glide path and localizer facilities, this distance may need to be increased.

Note 1: The distance of 90 m for codes 3 and 4 is based on an aircraft with a tail height of 20 m, a distance from the nose to the highest part of the tail of 52.7 m, and a nose height of 10 m holding at an angle of 45° or more with respect to the runway centre line, being clear of the obstacle free zone, and not accountable for the calculation of OCA/H.

Note 2: The 60 m distance for code number 2 is based on an aircraft with a tail height of 8 m, a distance from the nose to the highest part of the tail of 24.6 m, and a nose height of 5.2 m holding at a 45° or greater angle to the runway centre line while clear of the obstacle free zone.

Note 3: If the inner edge of the inner approach surface is more than 120 m wide, a distance of more than 90 m may be required to ensure that a holding aircraft is clear of the obstacle free zone for code number 4. A distance of 100 m, for example, is based on an aircraft with a tail height of 24 m, a distance from the nose to the highest part of the tail of 62.2 m, and a nose height of 10 m holding at an angle of 45° or more with respect to the runway centre line while remaining clear of the obstacle free zone.

Subpart E – Aprons

191.95 General information

(a) Aprons shall be provided where necessary to allow for the on- and off-loading of passengers, cargo, or mail, as well as aircraft servicing, without obstructing aerodrome traffic.

(b) The total apron area shall be sufficient to handle aerodrome traffic efficiently at its anticipated maximum density.

(c) Each section of an apron shall be capable of withstanding the traffic of the aircraft it is intended to serve, with due regard for the fact that certain sections will be subjected to a higher density of traffic and, as a result of slow moving or stationary aircraft, to greater stresses than a runway.

(d) Slopes on an apron, including those on an aircraft stand taxilane, shall be sufficient to prevent water accumulation on the apron's surface but kept as level as drainage requirements allow.

(e) The maximum slope on an aircraft stand shall not exceed 1 per cent.

(f) Following minimum clearances shall exist between an aircraft entering or exiting the stand and any adjacent building, aircraft on another stand, and other objects:

Table 8: Minimum clearances

Code letter	Clearance
A	3 m
B	3 m
C	4.5 m
D	7.5 m
E	7.5 m
F	7.5 m

(g) When special circumstances warrant, these clearances may be reduced at a nose-in aircraft stand designated by the code letters D, E, or F:

(1) between the terminal, including any fixed passenger bridge, and the nose of an aircraft; and

(2) over any portion of the stand equipped with an azimuth guidance system

Note: When designing aprons, it is necessary to consider the provision of service roads and the manoeuvring and storage area for ground equipment. See the Aerodrome Design Manual (Doc 9157), Part 2, for guidance on the storage of ground equipment).

Subpart F – Isolated aircraft parking position

191.101 General information

(a) An isolated aircraft parking position shall be designated or the aerodrome control tower shall be advised of an area suitable for parking an aircraft that is known or suspected to be the target of unlawful interference or that requires isolation from normal aerodrome activities for other reasons.

(b) The isolated aircraft parking position shall be as far from other parking positions, buildings, or public areas as possible but never less than 100 metres. Care shall be taken to avoid placing the position over underground utilities such as gas and aviation fuel and, to the extent possible, electrical or communication cables.

Subpart G – De-icing/anti-icing facilities

191.107 General information

(a) Aeroplane de-icing/anti-icing facilities shall be provided at an aerodrome where icing conditions are expected.

(b) De-icing/anti-icing facilities shall be available at aircraft stands or in designated remote areas along the taxiway leading to the take-off runway, provided that adequate drainage arrangements for the collection and safe disposal of excess de-icing/anti-icing fluids are available to avoid ground water contamination. Additionally, the effect of traffic volume and departure flow rates shall be considered.

Note 1: One of the primary factors influencing the location of a de-icing/anti-icing facility is ensuring that the anti-icing treatment is still effective at the end of taxiing and when the treated aeroplane receives take-off clearance.

Note 2: Remote facilities compensate for changing weather conditions when icing or blowing snow is expected along the aircraft taxi route to the take-off runway.

(c) The remote de-icing/anti-icing facility shall be located away from the obstacle limitation surfaces specified in Subpart H, shall not interfere with radio navigation aids, and shall be clearly visible from the air traffic control tower to clear the treated aeroplane.

(d) The remote de-icing/anti-icing facility shall be located to facilitate traffic flow, possibly via a bypass configuration. It shall not require any unusual taxiing manoeuvres into or out of the pads.

Note: To avoid degradation of the anti-icing treatment, the effects of the jet blast of a moving aircraft on other aeroplanes receiving the anti-icing treatment or taxiing behind must be considered.

(e) An aeroplane de-icing/anti-icing pad is comprised of two distinct areas:

- an inner area for parking the treated aircraft; and
- an outer area for the movement of two or more mobile de-icing/anti-icing equipment.

(f) A de-icing/anti-icing pad shall be the same size as the parking area required by the most demanding aeroplane in a given category, with a minimum of 3.8 metres of the clear paved area all around the aircraft for the movement of the de-icing/anti-icing vehicles.

Note: Where more than one deicing/anti-icing pad is provided, consideration should be given to providing deicing/anti-icing vehicle movement areas that do not overlap but are unique to each pad. Additionally, consideration should be given to the area being bypassed by other aeroplanes with the clearances specified in OTAR 191.113. Further guidance on de-icing/anti-icing pads is provided in OTAC 191-1.

(g) The number of de-icing/anti-icing pads required shall be determined by the meteorological conditions, the type of aircraft to be treated, the method of de-icing/anti-icing fluid application, the type and capacity of dispensing equipment used, and the departure flow rates.

Note: The design of an aeroplane de-icing/anti-icing facility must prioritise safe and effective aircraft operations. See the Manual on Aircraft Ground De-icing/Anti-icing Operations for more information (Doc 9640).

191.109 Slopes on de-icing/anti-icing pads

The de-icing/anti-icing pads shall have sufficient slopes to allow for adequate drainage of the area and to collect any excess de-icing/anti-icing fluid that runs off an aircraft. The longitudinal slope shall be kept to a minimum, and the transverse slope shall not exceed 1 per cent.

191.111 Strength of de-icing/anti-icing pads

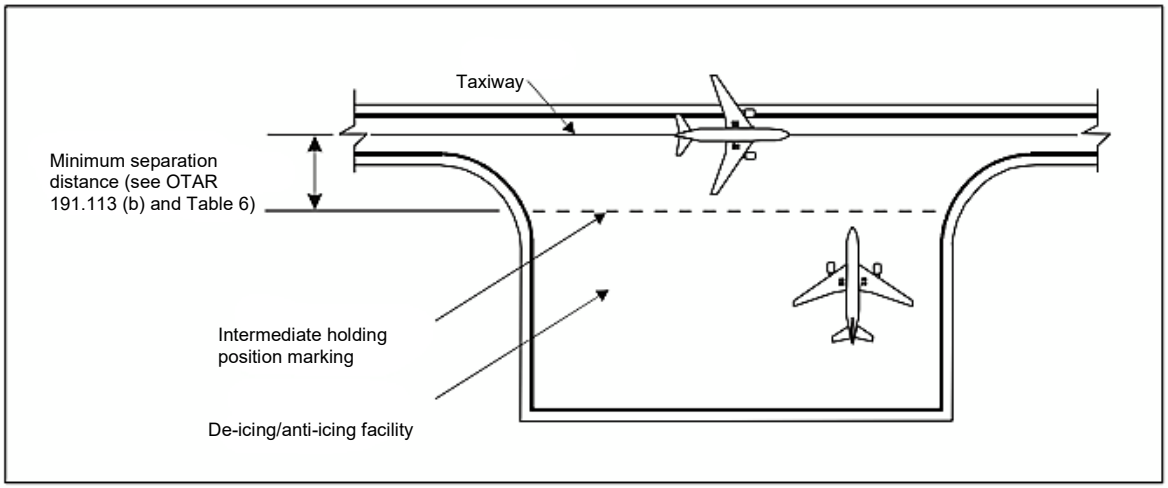
The de-icing/anti-icing pad shall be capable of withstanding the traffic of the aircraft it is intended to serve, with due regard for the fact that the de-icing/anti-icing pad (like an apron) will be subjected to a higher density of traffic and, as a result of slow-moving or stationary aircraft, to greater stresses than a runway.

191.113 Clearance distances on a de-icing/anti-icing pad

(a) A de-icing/anti-icing pad shall meet the minimum clearance requirements for aircraft stands specified in OTAR 191.95 (f). The minimum separation distances specified in Table 6 shall be provided if the pad layout includes bypass capability.

(b) Where the de-icing/anti-icing facility is adjacent to a regular taxiway, the minimum taxiway separation distance specified in Table 6 shall be provided.

Figure 4: Minimum separation distance on a de-icing/anti-icing facility



Source: ICAO Annex 14 Volume 1

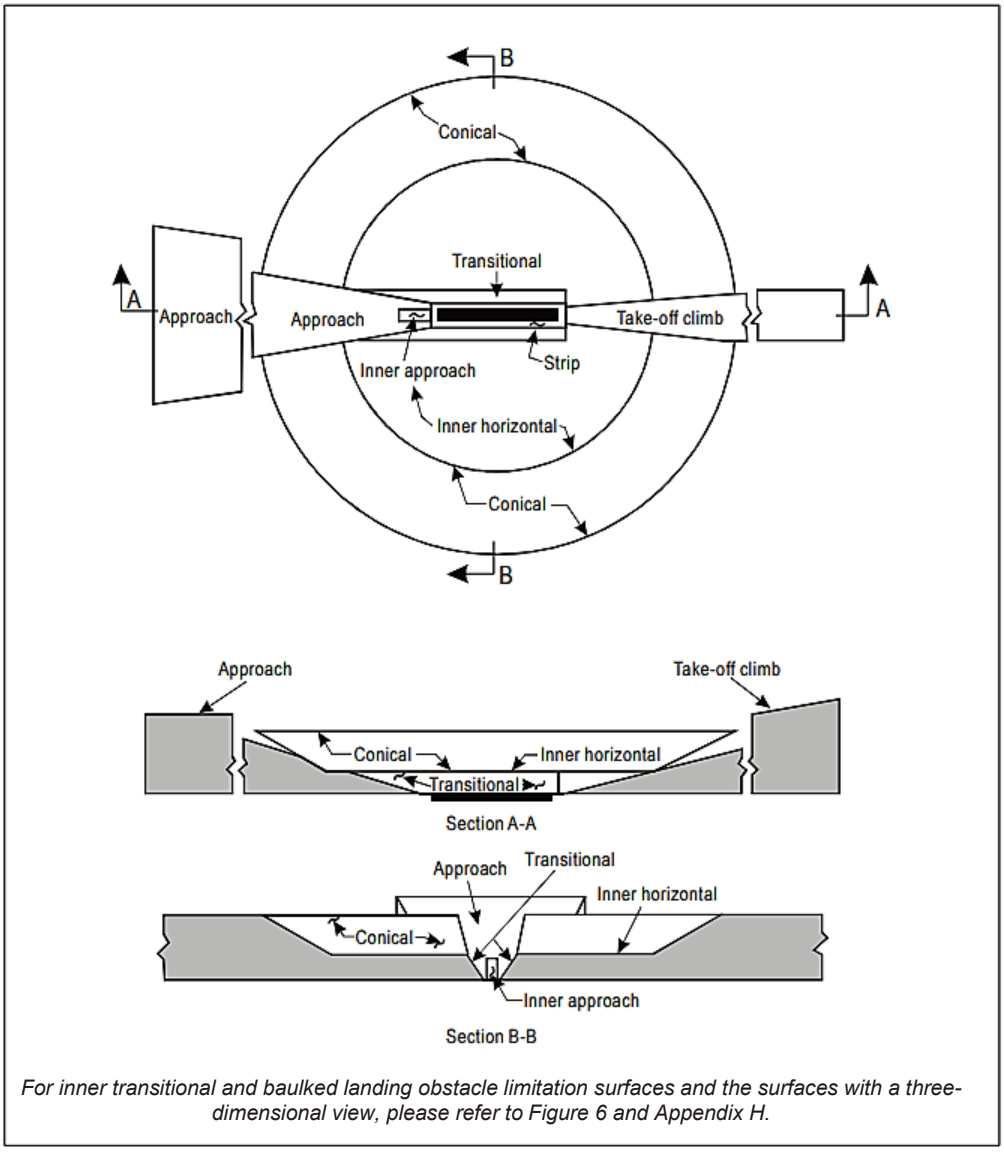
Subpart H – Obstacle limitation surfaces

The objectives of the specifications in this Subpart are to define the airspace around aerodromes that shall be kept free of obstacles to ensure the safety of the intended aircraft operations at the aerodromes and to prevent the aerodromes from becoming unusable due to the growth of obstacles around them. This is accomplished by establishing a set of obstacle limitation surfaces that determine the maximum height at which objects may protrude into the airspace

Objects that penetrate the obstacle limitation surfaces contained in this chapter may, under certain conditions, increase the obstacle clearance altitude/height for an instrument approach procedure or any associated visual circling procedure or have other operational effects on the design of flight procedures. OTAR Part 91 and The Procedures for Air Navigation Services — Aircraft Operations (PANS-OPS, Doc 8168) contain design criteria for flight procedures.

OTAR 191.193 (ee) to (ii) details the establishment and requirements for an obstacle protection surface for visual approach slope indicator systems.

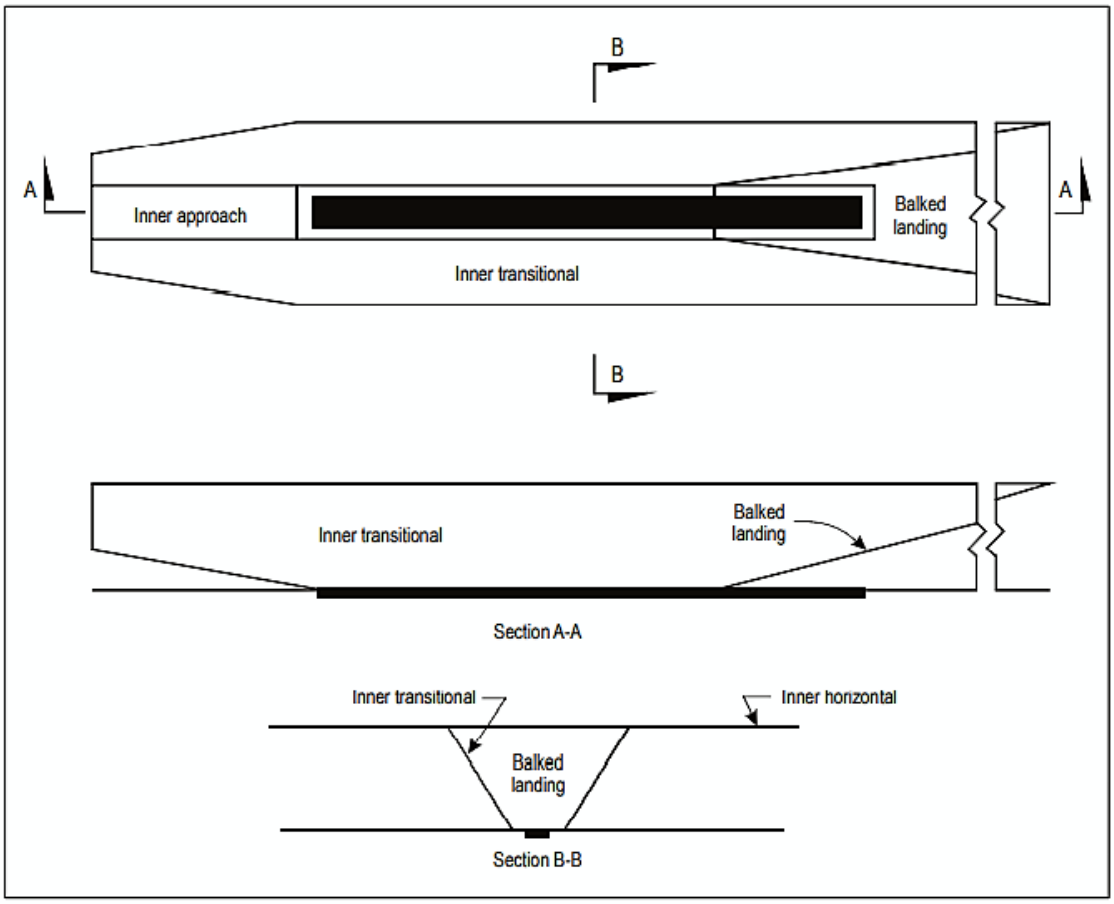
Figure 5: Obstacle limitation surfaces



For inner transitional and baulked landing obstacle limitation surfaces and the surfaces with a three-dimensional view, please refer to Figure 6 and Appendix H.

Source: ICAO Annex 14 Volume 1

Figure 6: Inner approach, inner transitional, and baulked landing obstacle limitation surfaces



Source: ICAO Annex 14 Volume 1

191.119 General information

(a) **Conical surface** is a surface sloping upwards and outwards from the periphery of the inner horizontal surface.

(1) The limits of the conical surface shall comprise the following:

(i) a lower edge coincident with the periphery of the inner horizontal surface; and

(ii) an upper edge located at a specified height above the inner horizontal surface.

(2) The slope of the conical surface shall be measured in a vertical plane perpendicular to the periphery of the inner horizontal surface

Note: The Airport Services Manual (Doc 9137), Part 6, contains instructions on providing an outer horizontal surface and its characteristics.

(b) **Inner horizontal surface** is a surface located in a horizontal plane above an aerodrome and its environs.

(1) The radius or outer limits of the inner horizontal surface shall be measured from a reference point or points established for such purpose.

Note: The shape of the inner horizontal surface need not necessarily be circular. OTAC 191-1 provides instructions on calculating the size of the inner horizontal surface.

(2) The height of the inner horizontal surface shall be measured above an elevation datum established for such purpose.

Note: OTAC 191-1 contains instructions on determining the elevation datum.

(c) **Approach surface** is an inclined plane or combination of planes preceding the threshold.

(1) The limits of the approach surface shall comprise the following:

(i) an inner edge of specified length, horizontal and perpendicular to the extended centre line of the runway and located at a specified distance before the threshold,

(ii) two sides originating at the ends of the inner edge and diverging uniformly at a specified rate from the extended centre line of the runway,

(iii) an outer edge parallel to the inner edge; and

(iv) the above surfaces shall be varied when lateral offset, offset, or curved approaches are utilsed. Specifically, two sides originating at the ends of the inner edge and diverging uniformly at a specified rate from the extended centre line of the lateral offset, offset or curved ground track.

(2) The elevation of the inner edge shall be equal to the elevation of the midpoint of the threshold.

(3) The slope(s) of the approach surface shall be measured in the vertical plane containing the runway centre line and shall continue to contain the centre line of any lateral offset or curved ground track.

Note: See Figure 6.

(d) **Inner approach surface** is a rectangular portion of the approach surface immediately preceding the threshold.

(1) The limits of the inner approach surface shall comprise the following:

(i) an inner edge coincident with the location of the inner edge of the approach surface but of its specified length,

(ii) two sides originating at the ends of the inner edge and extending parallel to the vertical plane containing the centre line of the runway; and

(iii) an outer edge parallel to the inner edge.

(e) **Transitional surface** is a complex surface along the side of the strip and part of the side of the approach surface that slopes upwards and outwards to the inner horizontal surface.

(1) The limits of a transitional surface shall comprise the following:

(i) a lower edge beginning at the intersection of the side of the approach surface with the inner horizontal surface and extending down the side of the approach surface to the inner edge of the approach surface and from there along the length of the strip parallel to the runway centre line; and

(ii) an upper edge located in the plane of the inner horizontal surface.

(2) The elevation of a point on the lower edge shall be:

(i) along the side of the approach surface — equal to the elevation of the approach surface at that point; and

(ii) along the strip — equal to the elevation of the nearest point on the runway centre line or its extension.

Note: As a result of the requirement of the elevation along the strip (OTAR 191.119 (2) (ii)), the transitional surface along the strip will be curved if the runway profile is curved or plane if the runway profile is straight. Depending on the runway profile, the transitional surface will also intersect with the inner horizontal surface in a curved or straight line.

(3) The slope of the transitional surface shall be measured in a vertical plane at right angles to the runway centre line.

(f) **Inner transitional surface** is similar to the transitional surface but closer to the runway.

(1) The inner transitional surface is intended to serve as the controlling obstacle limitation surface for navigation aids, aircraft, and other vehicles close to the runway and not be penetrated except by frangible objects. The transitional surface described in OTAR 191.119 (e) is intended to continue as the controlling obstacle limitation surface for structures such as buildings.

(2) The limits of an inner transitional surface shall comprise the following:

(i) a lower edge beginning at the end of the inner approach surface and extending down the side of the inner approach surface to the inner edge of that surface, from there along the strip parallel to the runway centre line to the inner edge of the baulked landing surface and from there up the side of the baulked landing surface to the point where the side intersects the inner horizontal surface; and

(ii) an upper edge located in the plane of the inner horizontal surface.

(3) The elevation of a point on the lower edge shall be:

(i) along the side of the inner approach surface and balked landing surface — equal to the elevation of the particular surface at that point; and

(ii) along the strip — equal to the elevation of the nearest point on the runway centre line or its extension.

Note: As a result of the requirement of the elevation along the strip (OTAR 191.119 (3) (ii)), the inner transitional surface of the strip will be curved if the runway profile is curved or plane if the runway profile is straight. Additionally, depending on the runway profile, the intersection of the inner transitional surface and the inner horizontal surface will be a curved or straight line.

(4) The slope of the inner transitional surface shall be measured in a vertical plane at right angles to the runway centre line.

(h) **Baulked landing surface** is an inclined plane located at a specified distance after the threshold, extending between the inner transitional surface.

(1) The limits of the baulked landing surface shall comprise the following:

(i) an inner edge horizontal and perpendicular to the centre line of the runway and located at a specified distance after the threshold,

(ii) two sides originating at the ends of the inner edge and diverging uniformly at a specified rate from the vertical plane containing the centre line of the runway; and

(iii) an outer edge parallel to the inner edge and located in the plane of the inner horizontal surface.

(2) The elevation of the inner edge shall be equal to the elevation of the runway centre line at the location of the inner edge.

(3) The slope of the baulked landing surface shall be measured in the vertical plane containing the runway centre line.

(i) **Take-off climb surface** is an inclined plane or other specified surface beyond the end of a runway or clearway.

(1) The limits of the take-off climb surface shall comprise the following:

(i) an inner edge horizontal and perpendicular to the centre line of the runway and located either at a specified distance beyond the end of the runway or at the end of the clearway when such is provided, and its length exceeds the specified distance,

(ii) two sides originating at the ends of the inner edge, diverging uniformly at a specified rate from the take-off track to a specified final width and continuing thereafter at that width for the remainder of the length of the take-off climb surface; and

(iii) an outer edge horizontal and perpendicular to the specified take-off track.

(2) The elevation of the inner edge shall be equal to the highest point on the extended runway centre line between the end of the runway and the inner edge, except that when a clearway is provided, the elevation shall be equal to the highest point on the ground on the centre line of the clearway.

(3) In the case of a straight take-off flight path, the slope of the take-off climb surface shall be measured in the vertical plane containing the runway centre line.

(4) In the case of a take-off flight path involving a turn, the take-off climb surface shall be a complex surface containing the horizontal normals to its centre line, and the slope of the centre line shall be the same as that for a straight take-off flight path.

191.121 Obstacle limitation requirements

(a) The requirements for obstacle limitation surfaces are specified in terms of the intended use of the runway, i.e. take-off or landing, and approach type. They are intended to be applied when the runway is used for such purposes. When operations are conducted in both directions of a runway, the function of some surfaces may be rendered obsolete due to the more stringent requirements of another lower surface.

(b) Obstacle limitation requirements for a non-instrument runway:

(1) the following obstacle limitation surfaces shall be established:

(i) conical surface,

(ii) inner horizontal surface,

(iii) approach surface, and

(iv) transitional surfaces.

(2) The heights and slopes of the surfaces shall not exceed, and their other dimensions shall not be less than, those specified in Table 9.

(3) No new objects or extensions of existing objects shall be permitted above an approach or transitional surface unless the new object or extension is shielded by an existing immovable object.

(4) New objects or extensions of existing objects shall not be permitted above the conical or inner horizontal surface unless an existing immovable object shields the object or an aeronautical study determines that the object will not adversely affect the safety or regularity of aeroplane operations.

Note: Part 6 of the Airport Services Manual (Doc 9137) describes the circumstances in which the shielding principle may be reasonably applied.

(5) Existing objects affixed to any surfaces required by OTAR 191.121 (b) shall be removed as far as practicable unless an existing immovable object shields the object or an aeronautical study determines that the object would not adversely impact the safety or significantly impair the regularity of aeroplane operations.

Note: Due to the transverse or longitudinal slopes of a strip, the inner edge or portions of the inner edge of the approach surface may occasionally be lower than the elevation of the strip. It is not intended that the strip be graded to conform to the inner edge of the approach surface, nor is it intended that terrain or objects above the approach surface but below the level of the strip be removed unless it is determined that they endanger aeroplanes.

(6) When considering the proposed construction, it is necessary to consider the possibility of future instrument runway development and the resulting requirement for more stringent obstacle limitation surfaces.

(c) Obstacle limitation requirements for a non-precision approach runway:

(1) For a non-precision approach runway, the following obstacle limitation surfaces shall be established:

(i) conical surface,

(ii) inner horizontal surface,

(iii) approach surface, and

(iv) transitional surfaces.

(2) Except for the horizontal section of the approach surface, the heights and slopes of the surfaces shall not exceed, and their other dimensions shall not be less than, those specified in Table 9. (see OTAR 191.121 (c) (3))

(3) Beyond the point at which the 2.5 per cent slope intersects, the approach surface shall be horizontal:

(i) a horizontal plane 150 m above the threshold elevation; or

(ii) the horizontal plane perpendicular to any top of the object that determines the obstacle clearance altitude/height (OCA/H),

whichever is the higher.

(4) No new objects or extensions of existing objects shall be permitted above an approach surface within 3 000 metres of the inner edge or above a transitional surface except when the new object or extension would be shielded by an existing immovable object.

(5) New objects or extensions of existing objects shall not be permitted above the approach surface beyond 3 000 metres from the inner edge, conical surface, or inner horizontal surface unless an existing immovable object shields the object or an aeronautical study determines that the object would not adversely impact the safety or regularity of aeroplane operations.

Note: The Airport Services Manual (Doc 9137), Part 6, describes the circumstances in which the shielding principle may be reasonably applied.

(6) Existing objects affixed to any surfaces required by OTAR 191.121 (c) (1) shall be removed as far as practicable unless an existing immovable object shields the object or an aeronautical study determines that the object would not jeopardise the safety or significantly impair the regularity of aeroplane operations.

Note: Due to a transverse of the strip or longitudinal slopes, the inner edge or portions of the inner edge of the approach surface may occasionally be lower than the elevation of the strip. It is not intended that the strip be graded to conform to the inner edge of the approach

surface, nor is it intended that terrain or objects above the approach surface but below the level of the stripe removed unless it is determined that they endanger aeroplanes.

(d) Obstacle limitation requirements for a precision approach runway:

(1) For a precision approach runway category I, the following obstacle limitation surfaces shall be established:

(i) conical surface,

(ii) inner horizontal surface,

(iii) inner approach surface,

(iv) approach surface,

(v) transitional surfaces,

(vi) inner transitional surfaces; and

(vii) baulked landing surface.

(2) For a precision approach runway category II or III, the following obstacle limitation surfaces shall be established:

(i) conical surface,

(ii) inner horizontal surface,

(iii) inner approach surface,

(iv) approach surface,

(v) transitional surfaces,

(vi) inner transitional surfaces; and

(vii) baulked landing surface.

(3) Except for the horizontal section of the approach surface, the heights and slopes of the surfaces shall not exceed, and their other dimensions shall not be less than, the values specified in Table 9.
For the requirements of the horizontal section of the approach surface, see OTAR 191.121 (d) (4).

(4) Beyond the point at which the 2.5 per cent slope intersects, the approach surface shall be horizontal:

(i) a horizontal plane 150 m above the threshold elevation; or

(ii) the horizontal plane that passes through the top of any object and establishes the clearance limit for obstacles;

whichever is the higher.

(5) Except for frangible objects located on the strip due to their function, fixed objects shall not be permitted above the inner approach surface, inner transitional surface, or baulked landing surface. During the use of the runway for landing, no mobile objects shall be permitted above these surfaces.

(6) New objects or extensions of existing objects shall not be permitted above an approach surface or a transitional surface unless the new object or extension is shielded by an existing immovable object.

(7) New objects or extensions of existing objects shall not be permitted above the conical surface and the inner horizontal surface unless an existing immovable object shields an object or an aeronautical study determines that the object will not adversely impact the safety or significantly affect the regularity of aeroplane operations.

(8) Existing objects above an approach surface, a transitional surface, the conical surface, and the inner horizontal surface shall be removed as far as practicable unless an existing immovable object shields an object or an object is determined after an aeronautical study that it would not adversely affect the safety or significantly affect the regularity of aeroplane operations.

Note 1: In some cases, the inner edge or portions of the inner edge of the approach surface may be below the corresponding elevation of the strip due to transverse or longitudinal slopes on the strip. It is not intended that the strip be graded to conform to the inner edge of the approach surface, nor that terrain or objects that are above the approach surface beyond the end of the strip but below the level of the strip be removed unless it is determined that they may endanger aircraft.

Note 2: See OTAR 191.321 for information regarding siting of equipment and installations in operational areas.

Note 3: Guidance on obstacle limitation surfaces for precision approach runways is provided in OTAC 191-1.

Table 9: Dimensions and slopes of obstacle limitation surfaces

APPROACH RUNWAYS										
	RUNWAY CLASSIFICATION									
Surface and dimensions[a]	Non-instrument Code number				Non-precision approach Code number			Precision approach category		
								I Code number		II or III Code number
	1	2	3	4	1,2	3	4	1,2	3,4	3,4
CONICAL										
Slope	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
Height	35 m	55 m	75 m	100 m	60 m	75 m	100 m	60 m	100 m	100 m
INNER HORIZONTAL										
Height	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m	45 m
Radius	2 000 m	2 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m	3 500 m	4 000 m	4 000 m
INNER APPROACH										
Width	—	—	—	—	—	—	—	90 m	120 m[e]	120 m[e]
Distance from threshold	—	—	—	—	—	—	—	60 m	60 m	60 m
Length	—	—	—	—	—	—	—	900 m	900 m	900 m
Slope								2.5%	2%	2%
APPROACH										
Length of the inner edge	60 m	80 m	150 m	150 m	140 m	280 m	280 m	140 m	280 m	280 m
Distance from threshold	30 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m	60 m
Divergence (each side)	10%	10%	10%	10%	15%	15%	15%	15%	15%	15%
First section										
Length	1 600 m	2 500 m	3 000 m	3 000 m	2 500 m	3 000 m	3 000 m	3 000 m	3 000 m	3 000 m
Slope	5%	4%	3.33%	2.5%	3.33%	2%	2%	2%	2%	2%
Second section										
Length	—	—	—	—	—	3 600 m[b]	3 600 m[b]	12 000 m	3 600 m[b]	3 600 m[b]
Slope	—	—	—	—	—	2.5%	2.5%	3%	2.5%	2.5%
Horizontal section										
Length	—	—	—	—	—	8 400 m[b]	8 400 m[b]	—	8 400 m[b]	8 400 m[b]
Total length	—	—	—	—	—	15 000 m	15 000 m	15 000 m	15 000 m	15 000 m
TRANSITIONAL										
Slope	20%	20%	14.3%	14.3%	20%	14.3%	14.3%	14.3%	14.3%	14.3%
INNER TRANSITIONAL										
Slope	—	—	—	—	—	—	—	40%	33.3%	33.3%
BAULKED LANDING SURFACE										
Length of the inner edge	—	—	—	—	—	—	—	90 m	120 m[e]	120 m[e]
Distance from threshold	—	—	—	—	—	—	—	c	1 800 m[d]	1 800 m[d]
Divergence (each side)	—	—	—	—	—	—	—	10%	10%	10%
Slope	—	—	—	—	—	—	—	4%	3.33%	3.33%

[a] All dimensions are measured horizontally unless specified otherwise.
[b] Variable length (see OTAR 191.121 (c) (3) or OTAR 191.125 (d)).
[c] Distance to the end of the strip.
[d] Or end of the runway, whichever is less.
[e] Where the code letter is F (Table 1), the width is increased to 140 m, except for aerodromes that can accommodate a code letter F aircraft equipped with digital avionics capable of providing steering commands to maintain an established track during the go-around manoeuvre.
Note: See OTAC 191-1 for further information.

(e) Obstacle limitation requirements for runways meant for take-off:

(1) The take-off climb surface shall be established for a runway meant for take-off.

(2) The surface dimensions shall not be less than those specified in Table 10, except that a shorter length may be used for the take-off climb surface if the shorter length is consistent with the procedural measures used to govern aeroplane outward flight.

(3) When critical operating conditions are to be accommodated, it is necessary to examine the aircraft operational characteristics for which the runway is intended to determine whether it is desirable to reduce the slope specified in Table 9. If the specified slope is reduced, the length of the take-off climb surface shall be increased proportionately to ensure protection to a height of 300 m.

Note: When local conditions are significantly different from sea level standard atmospheric conditions, it may be prudent to reduce the slope specified in Table 10. The extent to which this reduction occurs is determined by the divergence between local and sea level standard atmospheric conditions and the performance characteristics and operational requirements of the aircraft for which the runway is intended.

(4) No new objects or extensions of existing objects shall be permitted above a take-off climb surface unless the new object or extension is shielded by an existing immovable object.

Note: The Airport Services Manual (Doc 9137), Part 6, describes the circumstances in which the shielding principle may be reasonably applied.

(5) If no object reaches the 2 per cent (1:50) take-off climb surface, new objects shall be limited to maintaining the existing obstacle-free surface or a slope of 1.6 per cent (1:62.5).

(6) Existing objects that extend above a take-off climb surface shall be removed as far as possible unless the Governor determines that an existing immovable object shields the object or that the object would not adversely affect the safety or regularity of aeroplane operations.

Note: Due to the transverse slopes of a strip or clearway, portions of the inner edge of the take-off climb surface may be lower than the corresponding elevation of the strip or clearway. It is not intended that the strip or clearway be graded to match the inner edge of the take-off climb surface, nor is it intended that terrain or objects above the take-off climb surface but below the strip or the level of the clearway be removed unless it is determined that they endanger aeroplanes. Similar considerations apply at the intersection of a clearway and a strip with transverse slope differences.

Table 10: Dimensions of the surface

RUNWAYS MEANT FOR TAKE-OFF			
Surface and dimensions[a]	Code number		
	1	2	3 or 4
TAKE-OFF CLIMB			
Length of the inner edge	60 m	80 m	180 m
Distance from runway end[b]	30 m	60 m	60 m
Divergence (each side)	10%	10%	12.5%
Final width	380 m	380 m	1 200 m 1 800 m[c]
Length	1 600 m	2 500 m	15 000 m
Slope	5%	4%	2%[d]

[a] All dimensions are measured horizontally unless specified otherwise.
[b] The take-off climb surface starts at the end of the clearway if the clearway length exceeds the specified distance.
[c] 1 800 m when the intended track includes changes of heading greater than 15° for operations conducted in IMC, VMC by night.
[d] See OTAR 191.121 (e) (3) and (5).

191.123 Objects outside the obstacle limitation surfaces

(a) Arrangements shall be made to consult the Governor regarding proposed construction beyond the limits of the obstacle limitation surfaces that extend above a height determined by the Governor to allow for an aeronautical study of the effect of such construction on the operation of aeroplanes.

(b) In areas beyond the obstacle limitation surfaces, at least those objects that extend 150 metres or more above ground elevation shall be considered obstacles unless a special aeronautical study indicates that they do not pose a hazard to aircraft.

Note: This study may consider the nature of the operations under consideration and distinguish between day and night operations.

(c) Objects that do not project through the approach surface but would impair the optimal siting or performance of visual or non-visual aids shall be removed as far as practicable.

(d) Anything that may endanger aeroplanes in the movement area or the air within the limits of the inner horizontal and conical surfaces shall be regarded as an obstacle and removed so far as practicable.

Note: In some circumstances, objects that do not protrude above any of the surfaces listed in Subpart H may pose a hazard to aeroplanes, such as when one or more isolated objects are located near an aerodrome.

Subpart I – Indicators and signalling devices

191.129 Wind direction indicator

(a) At least one wind direction indicator shall be installed on an aerodrome.

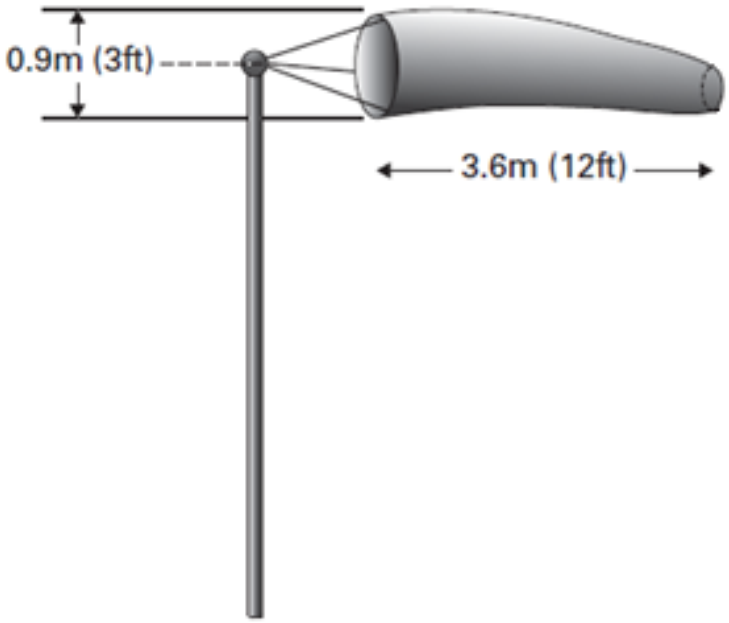
(b) A wind direction indicator shall be located so that it is visible from the aircraft in flight or the movement area and is free of the effects of nearby object-induced air disturbances.

(c) The wind direction indicator shall be shaped like a truncated cone made of fabric with a length of not less than 3.6 m and a diameter of not less than 0.9 m at the larger end. It shall be constructed in such a way that it clearly indicates the direction of the surface wind and the general indication of the wind speed. The colour or colours shall be chosen to make the wind direction indicator visible and understandable from a height of at least 300 metres, considering the surrounding environment. Wherever possible, a single colour shall be used, preferably white or orange. Where a combination of two colours is required to provide adequate visibility against changing backgrounds, it shall be orange and white, red and white, or black and white. It shall be arranged in five alternate bands, with the first and last bands being darker.

(d) A circular band 15 metres in diameter and 1.2 metres wide shall mark the location of at least one wind direction indicator. The band shall be centred on the wind direction indicator support and shall be bright, preferably white, to ensure adequate visibility.

(e) At least one wind indicator shall be illuminated at an aerodrome for night use.

Figure 7: Wind direction indicator



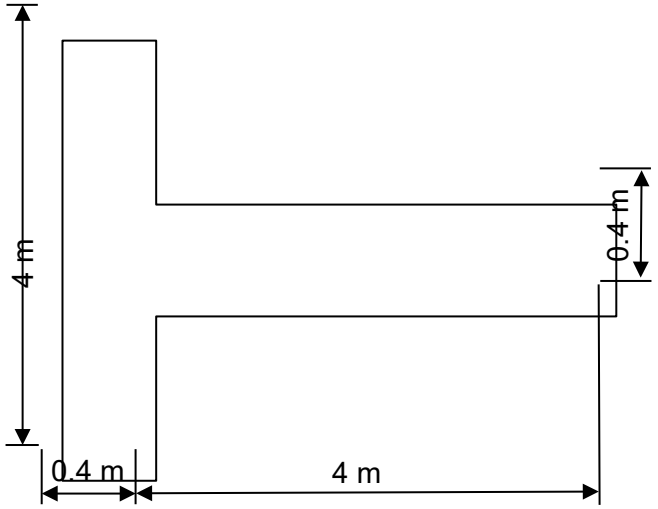
191.131 Landing direction indicator

(a) A landing direction indicator, if provided, shall be placed in a prominent location on the aerodrome.

(b) The landing direction indicator shall be in the form of a letter “T”.

(c) The shape and minimum dimensions of a landing “T” shall be as shown in Figure 8. The colour of the landing “T” shall be either white or orange, depending on the colour that best contrasts with the background against which the indicator will be viewed. Where required for use at night, the landing “T” shall either be illuminated or outlined by white lights.

Figure 8. Landing direction indicator



191.133 Signalling lamp

(a) At a controlled aerodrome, a signalling lamp shall be installed in the aerodrome control tower.

(b) A signalling lamp shall be able to produce red, green, and white signals, as well as:

(1) being aimed manually at any target as required;

(2) giving a signal in any one colour followed by a signal in either of the two other colours; and

(3) transmitting a message in any one of the three colours by Morse Code up to a speed of at least four words per minute.

(c) The beam spread shall be between 1° and 3°, with negligible light beyond 3°. The intensity of the coloured light shall not be less than 6 000 cd when the signalling lamp is intended for use during the day.

191.135 Signal panels and signal area.

(a) The signal area shall be visible from azimuth above an angle 10 degrees above the horizontal when viewed from a height of 300 metres.

(b) The signal area shall be an even horizontal surface at least 9 m square.

(c) The colour of the signal areashall contrast with the signal panels' colours and be surrounded by a white border at least 0.3 m wide.

Note: The fact that detailed specifications for a signal area are included in this section does not imply that one must be provided. On the necessity of providing ground signals, see OTAC 191-1. Visual ground signals are defined by their shape, colour, and use in Annex 2, Appendix 1. Their design is outlined in the Aerodrome Design Manual (Doc 9157) Part 4.

Subpart J – Markings

191.141 General information

(a) The markings of the more important runway, except for the runway side stripe marking, shall be displayed at an intersection of two (or more) runways, and the markings of the other runway(s) shall be interrupted. The more important side stripe markings of the runway may be continued or interrupted across the intersection.

(b) The following is a list of runways in order of importance for the display of runway markings:

(1) precision approach runway,

(2) non-precision approach runway; and

(3) non-instrument runway.

(c) The runway markings shall be displayed, and the taxiway markings shall be interrupted at an intersection of a runway and a taxiway, except that runway side stripe markings may be interrupted.

(d) Runway markings shall be white.

Note 1: It has been discovered that the visibility of white markings can be increased by outlining white markings in black on light-coloured runway surfaces.

Note 2: Using a suitable type of paint is preferable to minimise the risk of uneven friction characteristics on markings.

Note 3: Markings may be solid areas or a series of longitudinal stripes that produce the same effect as solid areas.

(e) Yellow markings shall be used on taxiways, runway turn pads, and aircraft stands.

(f) Apron safety lines shall be a visible colour that contrasts with the colour used for aircraft stand markings.

(g) At aerodromes with night-time operations, pavement markings shall be made of reflective materials to increase their visibility.

Note: Guidance on reflective materials is provided in the Aerodrome Design Manual (Doc 9157), Part 4.

(h) Wherever possible, an unpaved taxiway shall be marked with the same markings as paved taxiways.

191.143 Runway designation marking

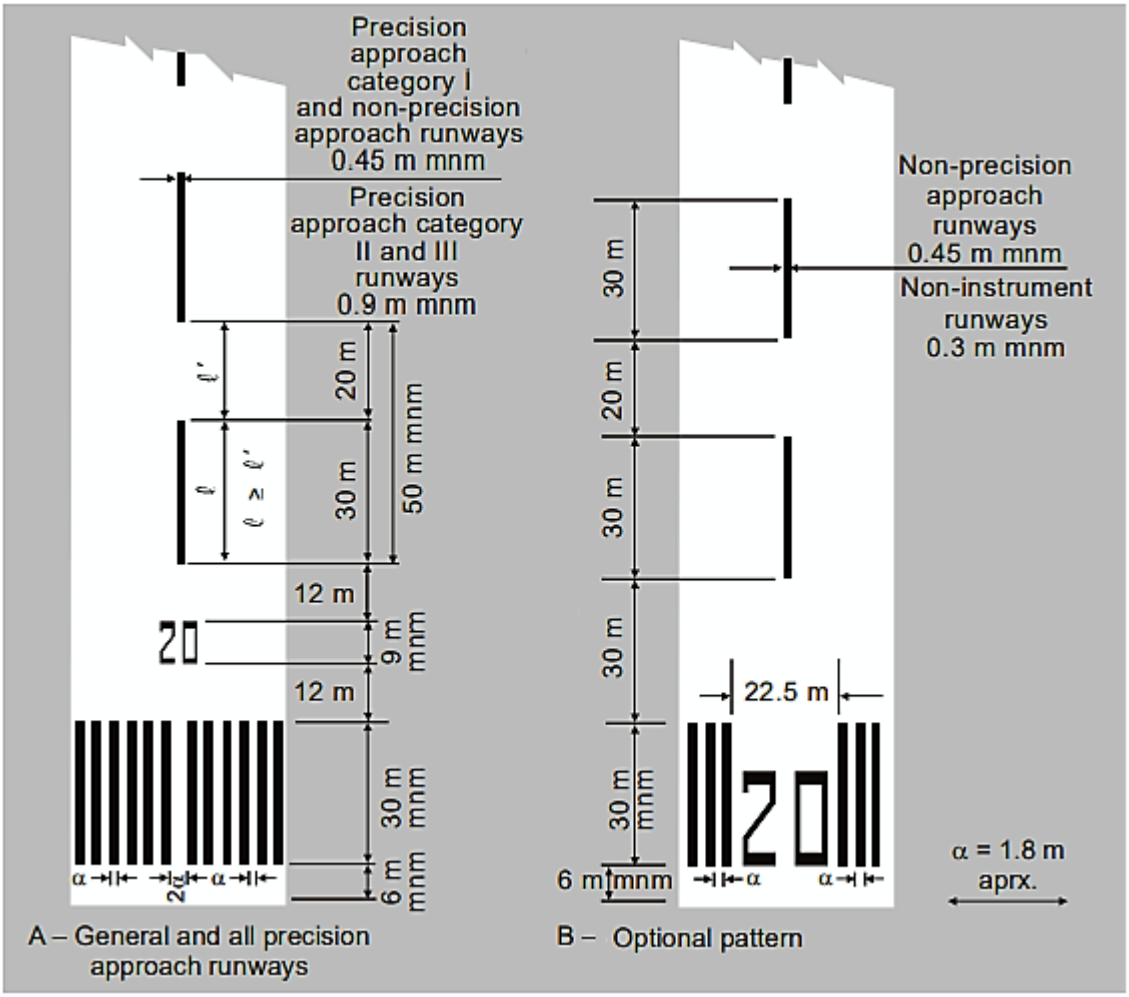
(a) A runway designation marking shall be provided at the thresholds of a paved runway.

(b) A runway designation marking shall be provided, so far as practicable, at the thresholds of an unpaved runway.

(c) A runway designation marking shall be placed at the appropriate threshold, as illustrated in Figure 9.

Note: If the runway threshold is moved away from the extremity of the runway, a sign indicating the designation of the runway may be provided for taking off aeroplanes.

Figure 9. Runway designation, centre line and threshold markings

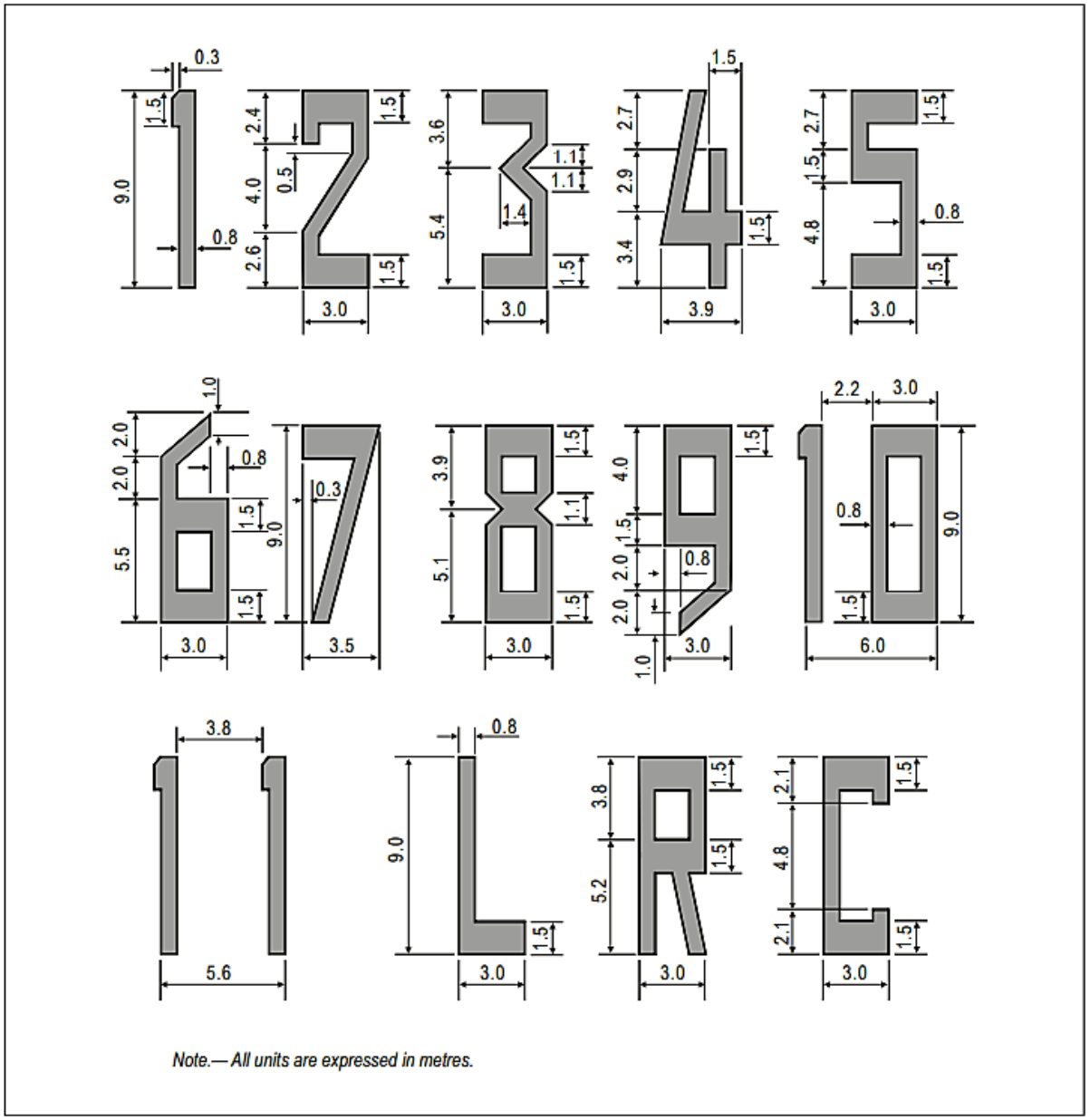


Source: ICAO Annex 14 Volume 1

(d) A runway designation marking shall consist of a two-digit number supplemented by a letter on parallel runways. On the runway, the two-digit number shall be the whole number closest to one-tenth of magnetic North when viewed from the approach direction.

(e) The numbers and letters shall be arranged in the manner and proportions depicted in Figure 10. The dimensions shall not be less than those shown in Figure 10, but where the numbers are integrated into the threshold marking, larger dimensions shall be used to fill the gap between the stripes of the threshold marking..

Figure 10. Form and proportions of numbers and letters for runway designation markings



Source: ICAO Annex 14 Volume 1

191.145 Runway centre line marking

(a) On paved runways, a runway centre line marking shall be provided.

(b) A runway centre line marking shall be placed along the runway centre line between the runway designation markings, as illustrated in Figure 9, except where the runway is interrupted in accordance with OTAR 191.141 (a).

(c) The runway centre line shall be marked with a continuous line of uniformly spaced stripes and gaps. A stripe plus a gap shall not be less than 50 m or greater than 75 m in length. Each stripe shall be at least as long as the gap or 30 metres, whichever is greater.

(d) The width of the stripes shall be not less than:

(1) 0.90 m on a precision approach category II and III runways,

(2) 0.45 m on non-precision approach runways where the code number is 3 or 4, and precision approach category I runways; and

(3) 0.30 m on non-precision approach runways where the code number is 1 or 2 and on non-instrument runways.

191.147 Threshold marking

(a) A threshold marking shall be provided at the threshold of a paved instrument runway and a paved non-instrument runway with a code number of 3 or 4 and intended for use by international commercial air transport.

(b) A threshold marking shall be provided at the threshold of a paved non-instrument runway with a code number of 3 or 4 that is intended for use by aircraft other than international commercial air transport.

(c) A threshold marking shall be provided, so far as practicable, at the unpaved runway thresholds.

Note: OTAC 191-1 depicts a marking method effective for designating downward slopes immediately before the threshold.

(d) The threshold marking stripes shall begin six metres from the threshold.

(e) A runway threshold marking shall consist of a pattern of uniform-width longitudinal stripes arranged symmetrically around the runway centre line, as illustrated in Figure 9 (A), for a runway width of 45 m. The number of stripes shall correspond to the runway width, except that on non-precision approach and non-instrument runways 45 metres in width or greater, they may be as shown in Figure 9 (C).

Table 11: Number of stripes

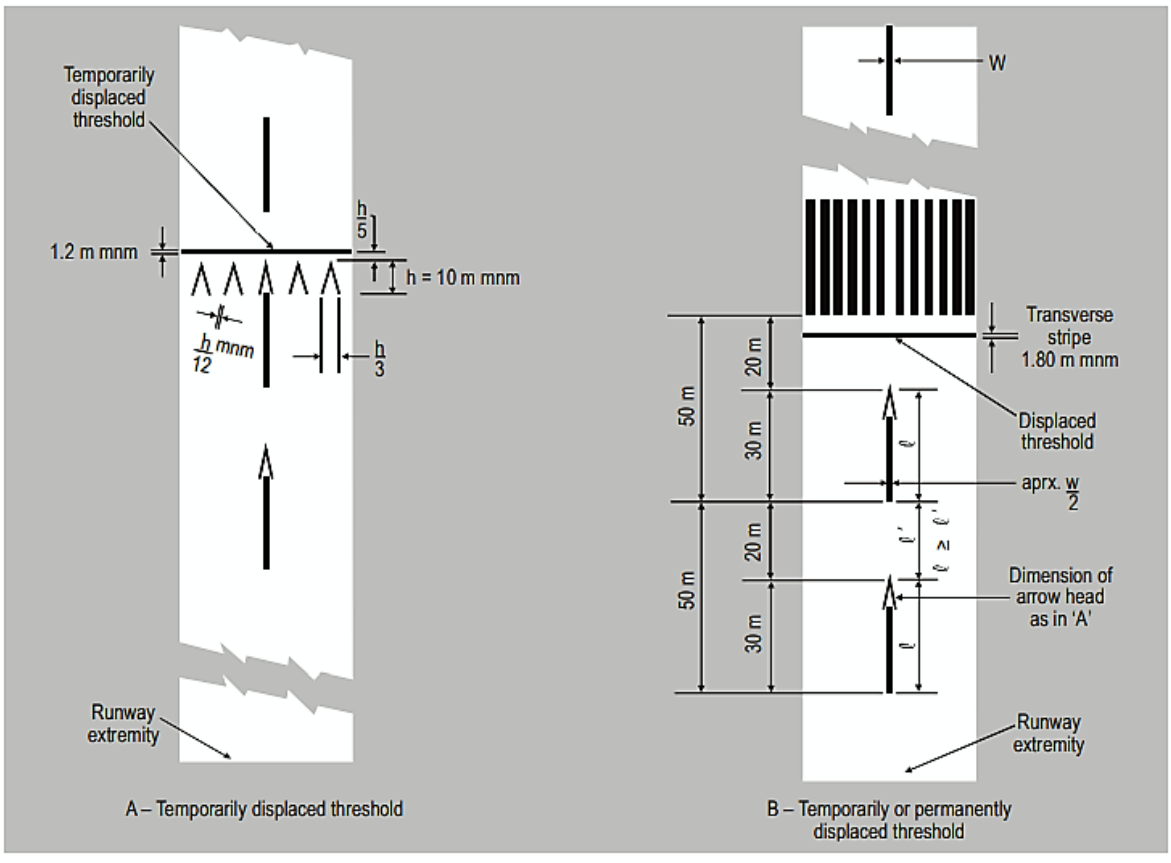
Runway width	Number of stripes
18 m	4
23 m	6
30 m	8
45 m	12
60 m	16

(f) The stripes shall extend laterally to within 3 metres of the runway edge or to a distance of 27 metres on either side of the runway centre line, whichever distance results in the shortest lateral distance. Where a runway designation marking is incorporated into a threshold marking, a minimum of three stripes on each side of the runway centre line shall be provided. If a runway designation marking is positioned above a threshold marking, the stripes shall continue across the runway. The stripes shall be at least 30 metres long and approximately 1.80 metres wide, with spacings of approximately 1.80 metres between them, except that where the stripes continue across a runway, a double spacing shall be used to separate the two stripes closest to the runway centre line. This spacing shall be 22.5 metres if the designation marking is included within the threshold marking.

(g) Where a threshold is offset from the extremity of the runway or the extremity of the runway is not square to the runway centre line, a transverse stripe, as shown in Figure 11 (B), shall be added to the threshold marking.

(h) A transverse stripe shall be at least 1.80 metres wide.

Figure 11. Displaced threshold markings



Source: ICAO Annex 14 Volume 1

(i) Where a runway threshold is permanently displaced, arrows conforming to Figure 11 (B) shall be installed on the portion of the runway immediately preceding the displaced threshold.

(j) When a runway threshold is temporarily displaced from its normal position, it shall be marked as shown in Figure 11 (A) or (B), except the runway centre line marking, which shall be converted to arrows.

Note 1: When a threshold is temporarily displaced for a brief period, it has been determined that using markers in the shape and colour of the displaced threshold marking is preferable to painting this marking on the runway.

Note 2: Closed markings, as described in OTAR 191.297 (d), are required to be provided when the runway before a displaced threshold is unfit for the surface movement of aircraft.

191.149 Aiming point marking

(a) When the code number is 2, 3, or 4, an aiming point marking shall be provided at each approach end of a paved instrument runway.

(b) When additional visibility of the aiming point is desired, an aiming point marking shall be provided at each approach end of:

(1) a paved non-instrument runway with a code number of 3 or 4,

(2) a paved instrument runway with a code number of 1.

(c) The aiming point marking shall begin no closer to the threshold than the distance indicated in the appropriate column of Table 12, except that the marking shall begin coincident with the visual approach slope origin on a runway equipped with a visual approach slope indicator system.

(d) Two conspicuous stripes shall constitute an aiming point marking. The dimensions of the stripes and the lateral spacing between their inner sides shall conform to the requirements specified in the appropriate column of Table 12. Where a touchdown zone marking is used, the lateral spacing between the markings shall be the same as the lateral spacing of the marking.

Table 12. Dimensions of the stripes

	Landing distance available			
Location and dimensions	Less than 800 m	800 m up to but not including 1 200 m	1 200 m up to but not including 2 400 m	2 400 m and above
Distance from threshold to the beginning of marking	150 m	250 m	300 m	400 m
Length of stripe[a]	30–45 m	30–45 m	45–60 m	45–60 m
Width of stripe	4 m	6 m	6–10 m[b]	6–10 m[b]
Width of stripe	6 m[c]	6 m[c]	6 m[c]	18–22.5 m

[a] The greater dimensions of the specified ranges are intended to be used where increased conspicuity is required.
[b] The lateral spacing may be varied within these limits to minimize the contamination of the marking by rubber deposits.
[c] These figures were deduced by reference to the outer main gear wheel span, which is element 2 of the aerodrome reference code in Table 1.

191.151 Touchdown zone marking

(a) A TDZ marking shall be provided in the TDZ of a paved precision approach runway with a code number of 2, 3, or 4.

(b) A TDZ marking shall be provided in the TDZ of a paved non-precision approach or non-instrument runway with a code number of 3 or 4. An additional conspicuity of the touchdown zone is desirable.

(c) A TDZ marking shall be composed of pairs of rectangular markings symmetrically disposed about the runway centre line, with the number of such pairs proportional to the available landing distance and, where the marking is to be displayed in both approach directions of a runway, the distance between the thresholds, as follows:

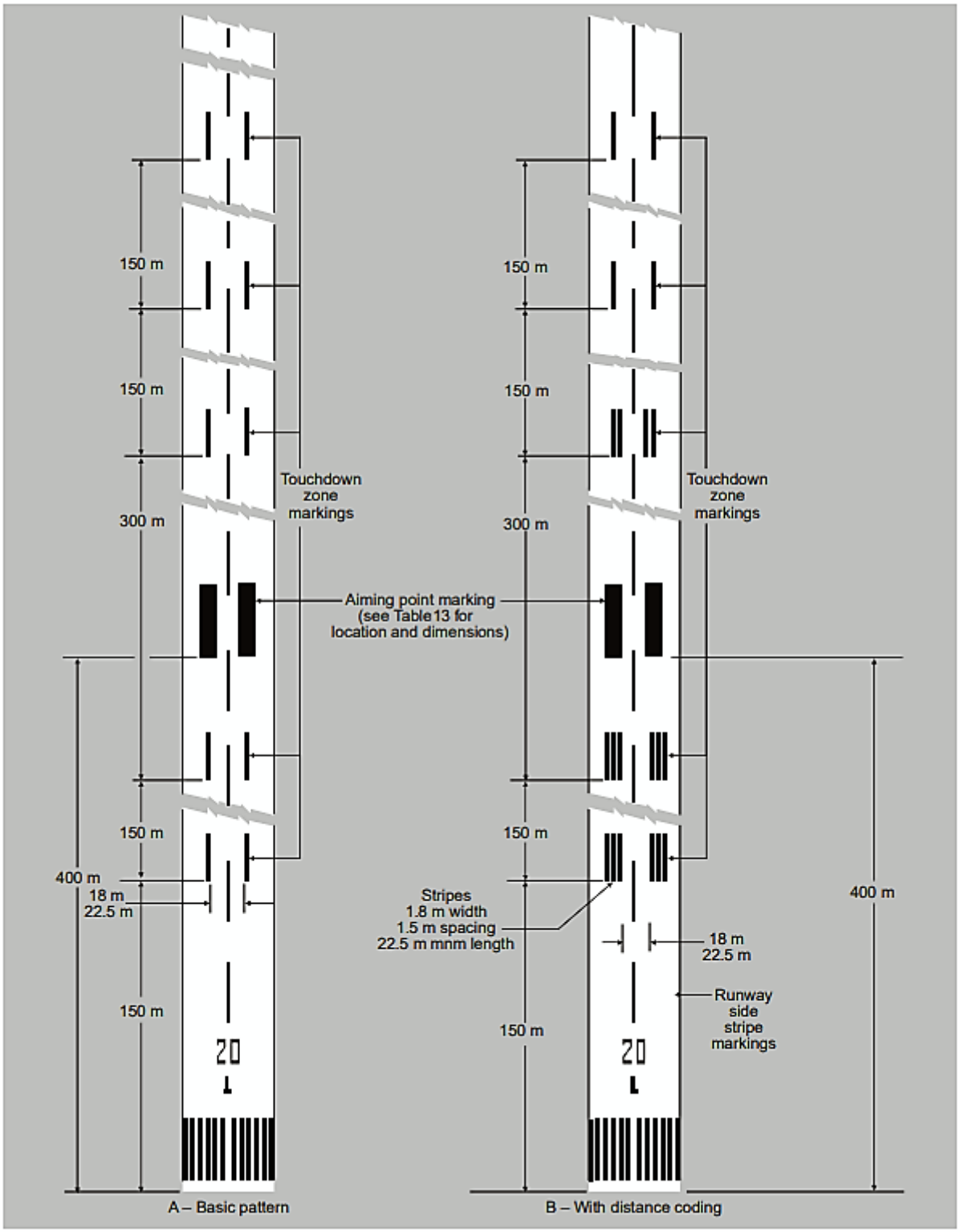
Table 13. Touchdown zone markings

Landing distance available or the distance between thresholds	Pair(s) of markings
less than 900 m	1
900 m up to but not including 1 200 m	2
1 200 m up to but not including 1 500 m	3
1 500 m up to but not including 2 400 m	4
2 400 m or more	6

(d) A TDZ shall be marked in one of the two patterns in Figure 11. The markings shall be at least 22.5 m long and 3 m wide for the pattern depicted in Figure 12 (A). Each stripe of each marking shall be at least 22.5 m long and 1.8 m wide, with a 1.5 m spacing between adjacent stripes, as shown in Figure 12 (B). If provided, the lateral spacing between the inner sides of the rectangles shall equal the spacing between the aiming point markings. In the absence of an aiming point marking, the lateral spacing between the inner sides of the rectangles shall correspond to the lateral spacing specified in Table 12 for the aiming point marking. The pairs of markings shall be spaced longitudinally by 150 metres beginning at the threshold, except that pairs of touchdown zone markings that coincide with or within 50 metres of an aiming point marking shall be deleted from the pattern.

(e) On a non-precision approach runway with code number 2, an additional pair of TDZ marking stripes 150 metres beyond the beginning of the aiming point marking shall be provided.

Figure 12: Aiming point and TDZ markings (illustrated for a runway with a length of 2 400 m or more)



Source: ICAO Annex 14 Volume 1

191.153 Runway side stripe marking

(a) A runway side stripe marking shall be provided between the thresholds of a paved runway where there is a lack of contrast between the runway edges and the shoulders or the surrounding terrain.

(b) A runway side stripe marking shall be provided on a precision approach runway, regardless of the contrast between the runway edges, shoulders, or surrounding terrain.

(c) A runway side stripe marking shall 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, unless the runway is greater than 60 m in width, in which case the stripes shall be 30 m from the runway centre line.

(d) If a runway turn pad is provided the runway side stripe marking shall be continued between the runway and the runway turn pad.

(e) On runways 30 metres or longer, a runway side stripe shall have an overall width of at least 0.9 metres, and on narrower runways, at least 0.45 metres.

191.155 Taxiway centre line marking

(a) Where the code number is 3 or 4, taxiway centre line marking shall be provided on a paved taxiway, de-icing/anti-icing facility, and apron to provide continuous guidance between the runway centre line and aircraft stands.

(b) Where the code number is 1 or 2, taxiway centre line marking shall be provided on a paved taxiway, de-icing/anti-icing facility, and apron to provide continuous guidance between the runway centre line and aircraft stands.

(c) Taxiway centre line marking shall be provided when a paved runway is part of a standard taxi-route and:

(1) there is no runway centre line marking,

(2) where the taxiway centre line is not coincident with the runway centre line.

(d) Enhanced taxiway centre line marking shall be provided where it is necessary to indicate the proximity of a runway-holding position.

Note: Improved taxiway centre line marking may be included in runway incursion prevention measures.

(e) Where provided, enhanced taxiway centre line marking shall be installed at each taxiway/runway intersection.

(f) On a straight section of the taxiway, the taxiway centre line marking shall be positioned parallel to the taxiway centre line. On a taxiway curve, the marking shall continue at a constant distance from the outside edge of the curve from the straight section of the taxiway (see OTAR 191.73 and Figure 2)

(g) At an intersection of a taxiway and a runway where the taxiway serves as an exit from the runway, the taxiway centre line marking shall curve into the runway centre line marking, as illustrated in Figures 13 and 32. Where the code number is 3 or 4, and where the code number is 1 or 2, the taxiway centre line marking shall be extended parallel to the runway centre line marking for a distance of at least 60 m beyond the point of tangency.

(h) Where a taxiway centre line is marked on a runway in accordance with OTAR 191.155 (c), the marking shall be placed on the designated taxiway centre line.

(i) Where indicated:

(1) An enhanced taxiway centre line marking shall extend from the runway-holding position Pattern A (as defined in Figure 13, Taxiway markings) in the direction of travel away from the runway to a distance of up to 47 metres (see Figure 14 (a))

(2) If the enhanced taxiway centre line marking intersects another runway-holding position marking, such as one for a precision approach category II or III runway, within 47 metres of the first runway-holding position marking. In that case, the enhanced taxiway centre line marking shall be interrupted 0.9 metres before and after the intersected runway-holding position marking. The enhanced taxiway centre line marking shall continue beyond the intersected runway-holding position marking (see Figure 14 (b)).

(3) If the enhanced taxiway centre line marking continues through a taxiway/taxiway intersection within 47 metres of the runway-holding position marking, the enhanced taxiway centre line marking shall be interrupted 1.5 metres before and after the point at which the intersected taxiway centre line crosses the enhanced taxiway centre line. The enhanced taxiway centre line marking shall extend beyond the taxiway/taxiway intersection for a minimum of three dashed line segments or 47 metres from start to finish (see Figure 14 (c)).

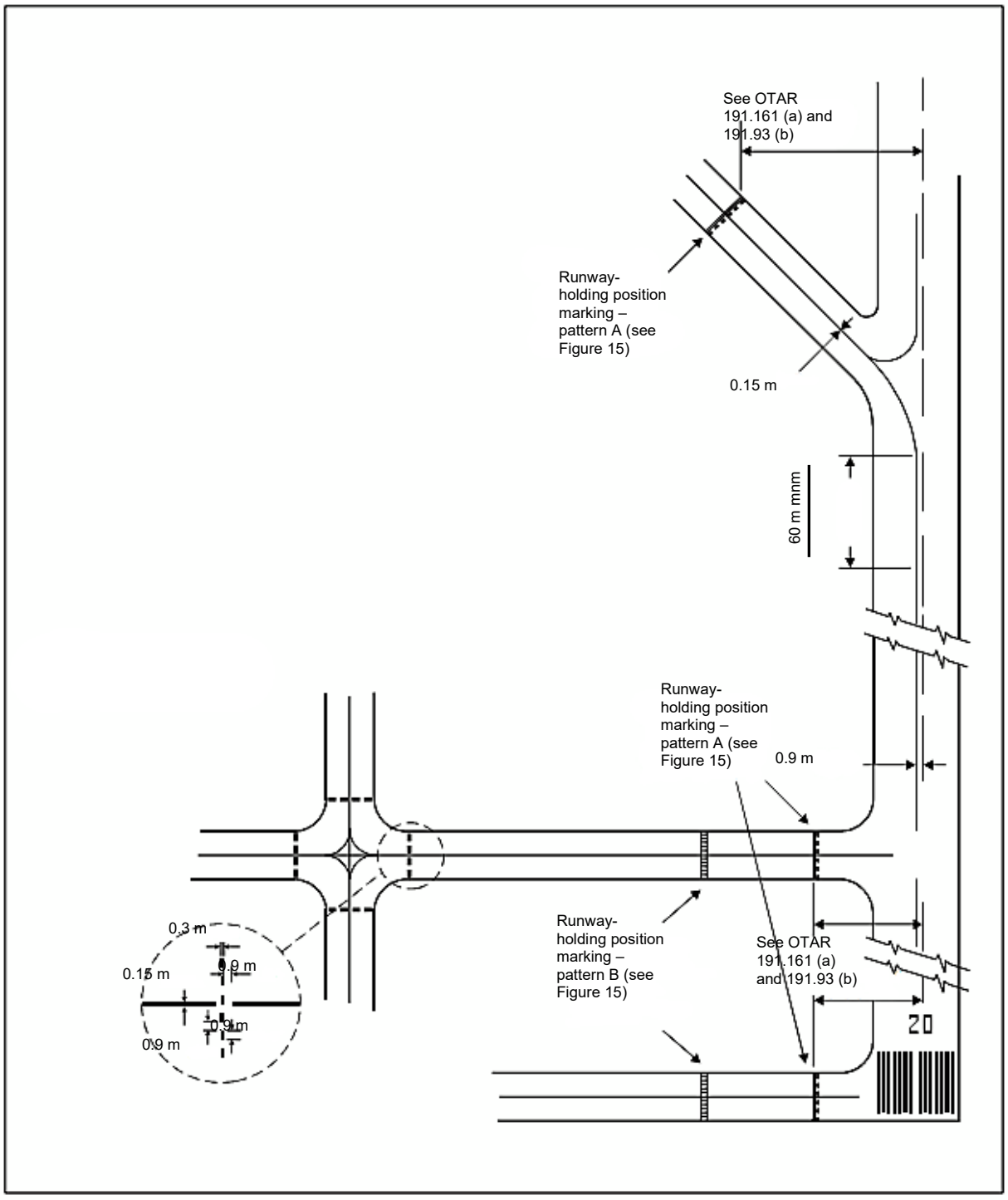
(4) Where two taxiway centre lines meet at or before the runway-holding position marking, the inner dashed line shall be at least 3 metres long (see Figure 14 (d)).

(5) Where two opposing runway-holding position markings are located within a distance of less than 94 metres from one another, the enhanced taxiway centre line markings shall extend the entire distance. The enhanced taxiway centre line markings shall extend no further than either runway-holding position marking (see Figure 14 (e)).

(j) A taxiway centre line marking shall be at least 15 cm wide and continuous in length, except where it intersects with a runway-holding position marking or an intermediate holding position marking, as illustrated in Figure 13.

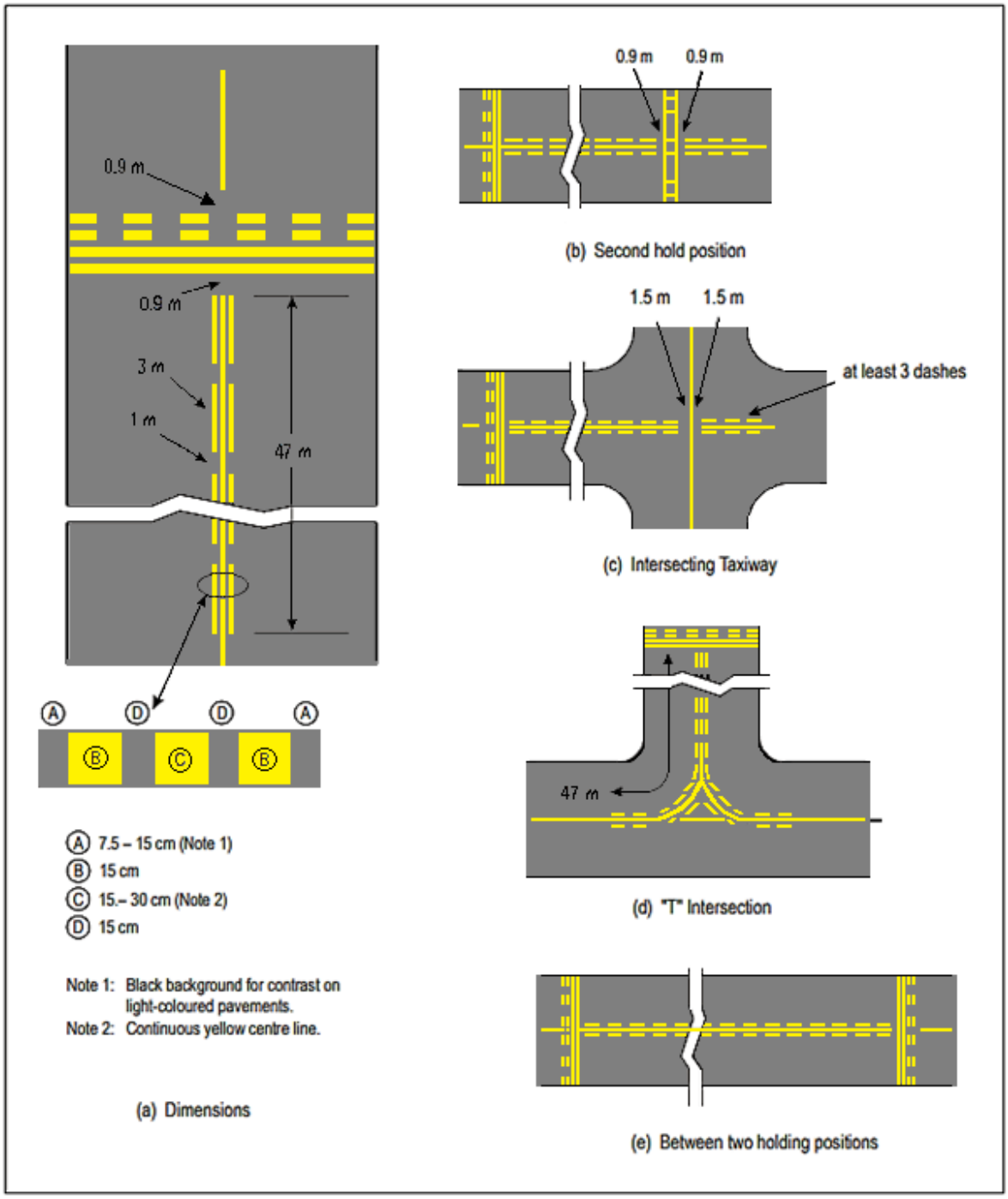
(k) Line markings for the enhanced taxiway centre shall be as shown in Figure 14.

Figure 13. Taxiway markings (shown with basic runway markings)



Source: ICAO Annex 14 Volume 1

Figure 14: Enhanced taxiway centre line marking



191.157 Runway turn pad marking

(a) Where a runway turn pad is placed, a runway turn pad marking shall provide continuous guidance to enable an aeroplane to complete a 180-degree turn and align with the runway centre line.

(b) The runway turn pad markings shall be curved inward from the runway centre line. The radius of the curve shall be compatible with the manoeuvrability and normal taxiing speeds of the aircraft intended to use the runway turn pad. The angle at which the runway turn pad marking intersects the runway centre line shall not exceed 30 degrees.

(c) Where the code number is 3 or 4, and where the code number is 1 or 2, the runway turn pad marking shall be extended parallel to the runway centre line marking for a distance of at least 60 m beyond the point of tangency.

(d) A runway turn pad marking shall direct the aeoroplane so that it can taxi straight towards the point where a 180-degree turn is to be made. The straight portion of the runway turn pad marking shall be parallel to the outer edge of the runway turn pad.

(e) The curve that enables the aeroplane to negotiate a 180-degree turn shall be designed with a nose wheel steering angle of no more than 45 degrees in mind.

(f) The turn pad marking shall be designed in such a way that, when the cockpit of the aeroplane remains above the runway turn pad marking, the clearance distance between any wheel of the aircraft landing gear and the runway turn pad edge shall not be less than that specified in OTAR 191.59 (f).

Note: For manoeuvrability, providing greater wheel-to-edge clearance for codes E and F aeroplanes may be appropriate.

(g) A runway turn pad marking shall be at least 15 cm in width and continuous in length.

191.159 Runway-holding position marking

(a) A runway-holding position marking shall be displayed along a runway-holding position.

Note: See OTAR 191.251 for information on the signage required at runway-holding positions.

(b) The runway-holding position marking shall be shown in Figure 13, pattern A, at a taxiway intersection and a non-instrument, non-precision approach or take-off runway.

(c) Where a single runway-holding position is provided at a taxiway intersection and a precision approach category I, II, or III runway, the runway-holding position markings shall conform to the pattern A shown in Figure 13. Where two or three runway-holding positions are provided at such an intersection, the markings for the runway-holding position closest to the runway shall be as shown in Figure 13, pattern A, and the markings for the runway-holding position farther from the runway shall be as shown in Figure 13, pattern B.

(d) At a runway-holding position established in accordance with OTAR 191.93 (c), the runway-holding position marking shall be as shown in Figure 13, pattern A.

(e) The dimensions of runway-holding position markings shall be as shown in Figure 15, either pattern A1 or B1.

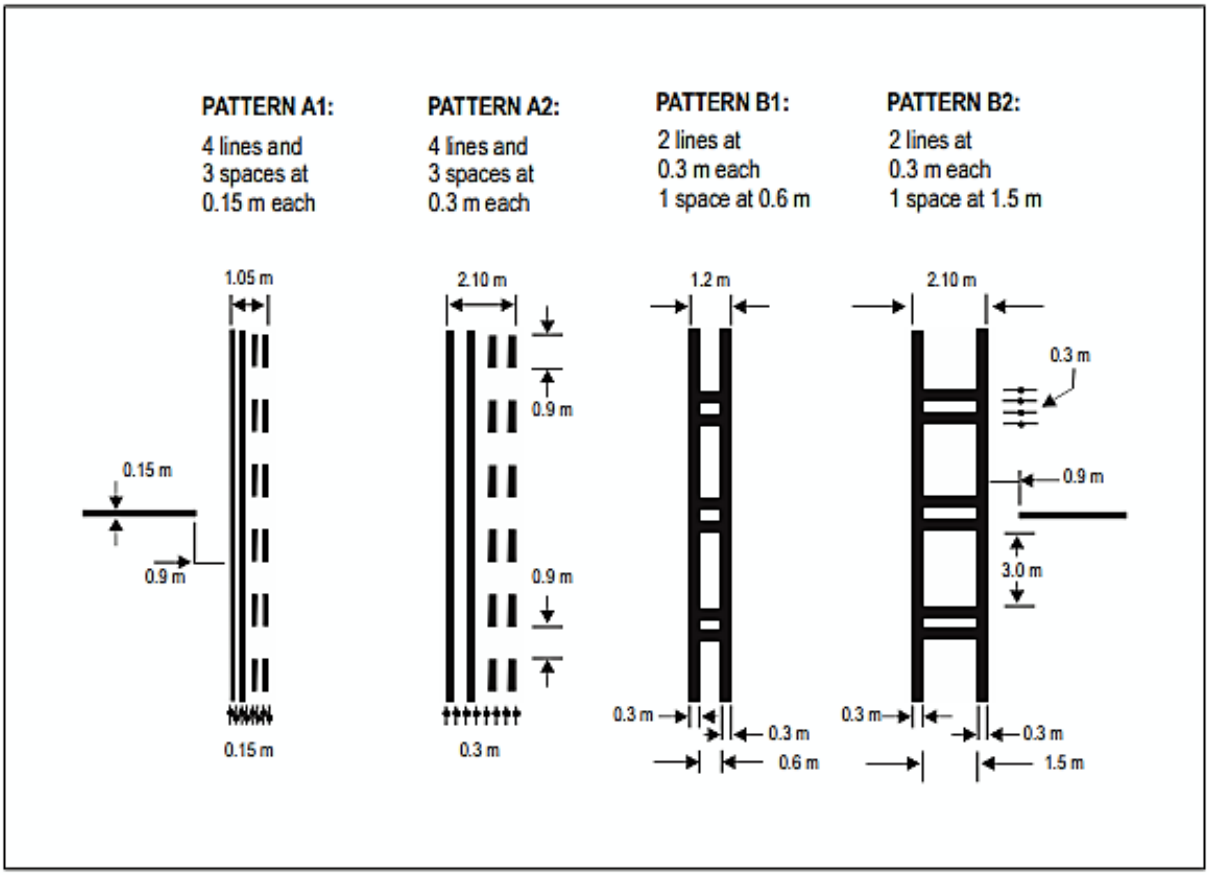
(f) Where increased visibility of the runway-holding position is required, the dimensions of the runway-holding position marking shall conform to those shown in Figure 15, pattern A2 or pattern B2, as applicable.

Note: A more visible runway-holding position may be required to avoid incursion risks.

(g) Where a pattern B runway-holding position marking is located in an area that would exceed 60 metres in length, the terms "CAT II" or "CAT III" shall be marked on the surface at the ends of the runway-holding position marking and at 45 metre intervals between successive marks. The letters shall be no less than 1.8 m high and no more than 0.9 m beyond the holding position marking.

(h) At a runway/runway intersection, the runway-holding position marking shall be perpendicular to the runway centre line forming part of the standard taxi route. The marking pattern shall be as illustrated in Figure 15, pattern A2.

Figure 15: Runway-holding position markings



Source: ICAO Annex 14 Volume 1

191.161 Intermediate holding position marking

(a) An intermediate holding position marking shall be displayed in addition to an intermediate holding position.

(b) An intermediate holding position marking shall be displayed at the exit boundary of a remote de-icing/anti-icing facility adjacent to a taxiway.

(c) When an intermediate holding position marking is displayed at a paved taxiway intersection, it shall be placed across the taxiway and far enough away from the intersecting near edge of the taxiway to ensure safe clearance between taxiing aircraft. Where a stop bar or intermediate holding position lights are provided, it shall be aligned with them.

(d) The distance between an intermediate holding position marking at the exit boundary of a remote de-icing/anti-icing facility and the centre line of the adjacent taxiway shall not be less than the dimension specified in Table 6.

(e) An intermediate holding position marking shall consist of a single broken line, as shown in Figure 14 and Figure 16.

Figure 16: Intermediate taxi-holding position marking

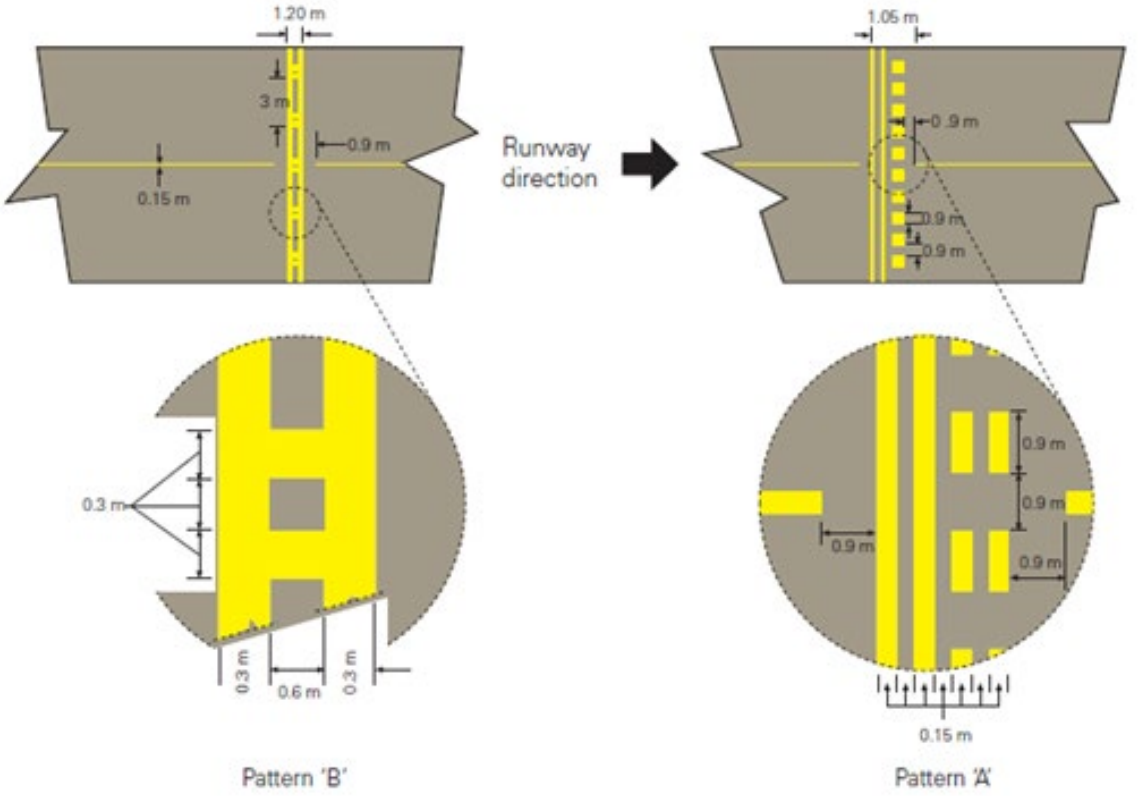
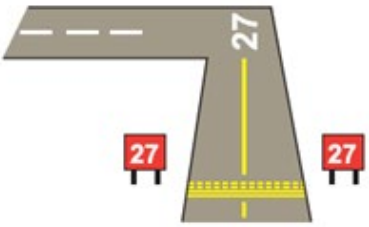
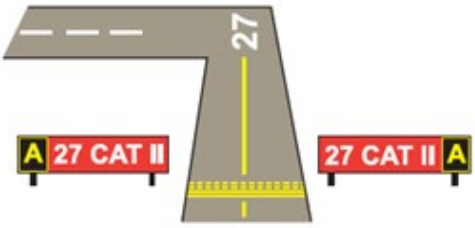
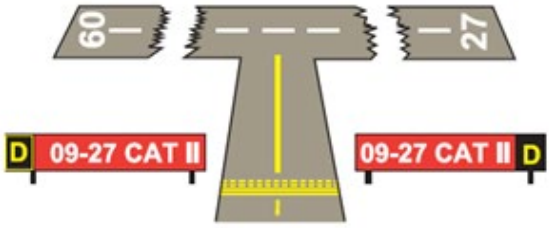


Figure 17: Typical runway taxi-holding position signs and associated taxiway marking

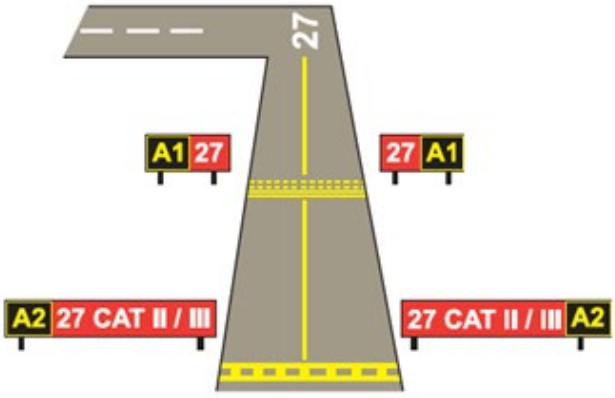


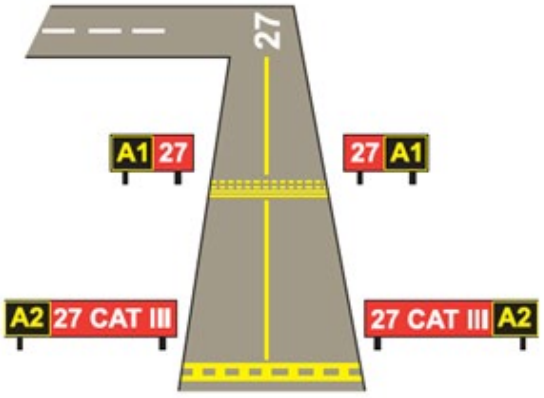
The signs at intermediate taxiway entrances are handed to show a left turn is required to reach the threshold of runway 09 and a right turn to reach the threshold of runway 27



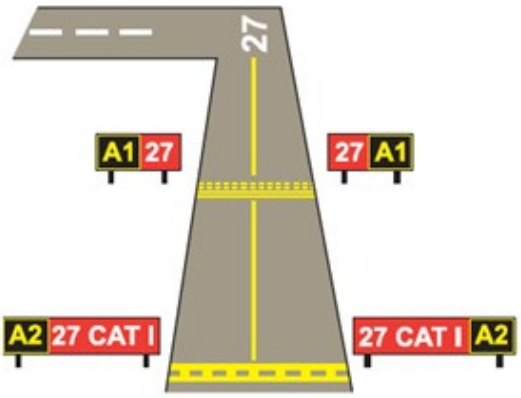


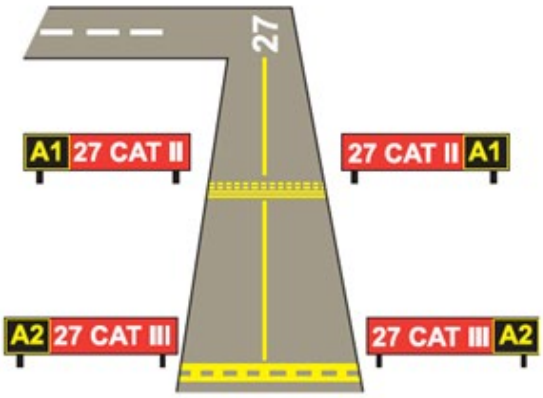
The signs at intermediate taxiway entrances are handed to show a left turn is required to reach the threshold of runway 09 and a right turn to reach the threshold of runway 27





Where the ILS Runway Taxi-Holding Position is at such a distance from the runway that it would hinder the expeditious flow of traffic in VMC, a non-instrument Runway Taxi-Holding Position shall also be established closer to the runway





Where the ILS Runway Taxi-Holding Position is at such a distance from the runway that it would hinder the expeditious flow of traffic in VMC, a non-instrument Runway Taxi-Holding Position shall also be established closer to the runway

191.163 VOR aerodrome checkpoint marking

(a) When a VOR aerodrome checkpoint is established, it shall be marked with a VOR aerodrome checkpoint sign (See OTAR 191.255)

(b) A VOR aerodrome checkpoint marking shall be centred on where an aircraft will be parked to receive the correct VOR signal.

(c) A VOR aerodrome checkpoint marking shall be a 6 m diameter circle with a 15 cm line width (see Figure 18 (A)).

(d) When an aircraft shall be aligned in a specific direction, a line that passes through the centre of the circle on the desired azimuth shall be provided. The line shall be 15 cm wide (see Figure 18 (B)). The line shall extend 6 m outside the circle and terminate in an arrowhead in the desired direction of heading.

(e) A VOR aerodrome checkpoint marking shall preferably be white, but it shall not be the same colour as the taxiway markings.

Note 1: Markings may be bordered with black to provide contrast.

Note 2: Annex 10, Volume I, Attachment E, guides the selection of locations for VOR aerodrome checkpoints.

191.165 Aircraft stand marking

(a) Aircraft stand markings for designated parking positions shall be provided on a paved apron and at a de-icing/anti-icing facility.

Note: Guidance on the layout of aircraft stand markings is provided in the OTAC 191-1

(b) Aircraft stand markings on a paved apron and a de-icing/anti-icing facility shall be located to provide the clearances specified in OTAR 191.99 (f), (g) and in OTAR 191.11 (e), (f) and (g), respectively, when the nose wheel follows the stand marking.

(c) As required by the parking configuration and to supplement other parking aids, aircraft stand markings shall include stand identification, a lead-in line, a turn bar, a turning line, an alignment bar, a stop line, and a lead-out line.

(d) A short distance after the start of the lead-in line, an aircraft stand identification (letter and/or number) shall be included. The identification height shall be sufficient to be visible from the cockpit of the aircraft using the stand.

(e) When two sets of aircraft stand markings are superimposed on each other to allow for more flexible use of the apron, and it is difficult to determine which stand marking shall be followed or if safety would be compromised if the incorrect marking was followed, identification of the aircraft for which each set of markings is intended shall be added to the stand identification.

(f) Lead-in, turning, and lead-out lines shall be continuous in length and no less than 15 cm wide. When one or more sets of stand markings are superimposed on a stand marking, the lines for the most demanding aircraft shall be continuous, and the lines for other aircraft shall be broken.

(g) The curved portions of lead-in, turning, and lead-out lines shall have radii appropriate for the most demanding aircraft type for which the markings are intended.

(h) When it is intended for an aircraft to move in only one direction, arrows pointing in that direction shall be added as part of the lead-in and lead-out lines.

(i) At the point of initiation of any intended turn, a turn bar shall be located at right angles to the lead-in line, abeam the left pilot position. It shall have a length and width of at least 6 m and 15 cm, respectively, and an arrowhead to indicate the turn direction.

Note: The distances between the turn bar and the lead-in line must be maintained differently depending on the aircraft type, considering the field of view of the pilot.

(j) If more than one turn bar and/or stop line are needed, they shall be coded.

(k) An alignment bar shall be placed parallel to 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 shall be no less than 15 cm wide.

(l) At the intended point of stop, a stop line shall be placed at right angles to the alignment bar, abeam the left pilot position. Its length and width shall be no less than 6 m and 15 cm, respectively.

Note: The distances between the stop line and the lead-in line may vary depending on the aircraft type, taking into account the field of view of the pilot.

191.167 Apron safety lines

(a) Apron safety lines shall be placed on a paved apron as parking configurations and ground facilities require.

(b) To maintain a safe separation from aircraft, the apron safety lines shall be located to clearly define areas intended for use by ground vehicles and other aircraft servicing equipment, etc.

(c) Apron safety lines shall include wing tip clearance lines and service road boundary lines if parking configurations and ground facilities require them.

(d) A safety line for an apron shall be continuous in length and at least 10 cm wide.

Note: Guidance on apron safety lines is contained in OTAC 191-1.

191.169 Road-holding position marking

(a) A road-holding position marking shall be provided at each road entrance to a runway.

(b) The marking for the road-holding position shall be placed across the road from the holding position.

(c) The marking of the road-holding position shall comply with applicable local road traffic regulations.

191.171 Mandatory instruction marking

(a) Where the installation of a mandatory instruction sign in accordance with OTAR 191.251 (a) is impractical, a mandatory instruction marking shall be provided on the pavement surface.

(b) A mandatory instruction marking shall supplement a mandatory instruction sign when necessary for operational reasons, such as on taxiways wider than 60 metres or to assist in preventing runway incursions.

(c) The mandatory instruction markings on taxiways with the letter code A, B, C, or D shall be evenly spaced across the taxiway and on the holding side of the runway-holding position marking, as illustrated in Figure 18 (A). The distance between the nearest edge of the marking and the runway-holding position or taxiway centre line marking shall be at least 1 m.

(d) On taxiways with the code letter E or F, the mandatory instruction marking shall be located on both sides of the taxiway centre line and the holding side of the runway-holding position marking, as illustrated in Figure 18 (B). The distance between the nearest edge of the marking and the runway-holding position or taxiway centre line marking shall be at least 1 m.

(e) A mandatory instruction marking shall not be placed on a runway unless it is operationally necessary.

(f) An inscription in white on a red background shall constitute a mandatory instruction marking. Except for a NO ENTRY indication, the inscription shall contain the same information as the associated mandatory instruction sign.

(g) A NO ENTRY sign shall consist of a white inscription reading NO ENTRY set against a red background.

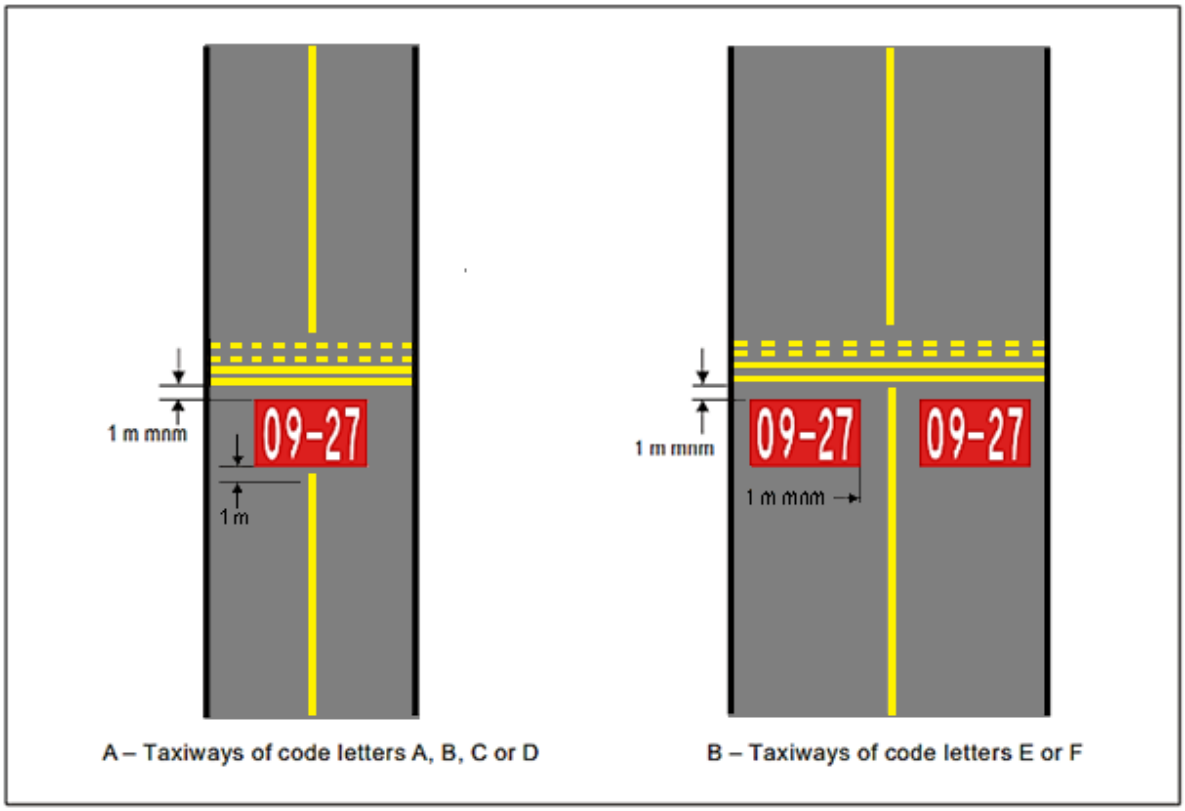
(h) Where the marking and the pavement surface do not contrast sufficiently, the mandatory instruction marking shall include an appropriate border, preferably white or black.

(i) The character height shall be 4 m for inscriptions beginning with the letters C, D, E, or F and 2 m for inscriptions beginning with the letters A or B. Inscriptions shall follow the format and proportions specified in Appendix 3.

(j) The background shall be rectangular and extend at least 0.5 m laterally and vertically beyond the extremities of the inscription.

Note: Guidance on mandatory instruction marking is provided in OTAC 191-1.

Figure 18. Mandatory instruction marking



191.173 Information marking

(a) Where an information sign would normally be installed but is deemed impractical by the appropriate authority, an information marking shall be displayed on the pavement surface.

(b) Where an information sign is required for operational purposes, it shall be supplemented by an information marking.

(c) Before and following complex taxiway intersections, an information (location/direction) marking shall be displayed, and where operational experience indicates that the addition of a taxiway location marking could aid flight crew ground navigation.

(d) Information (location) marking shall be displayed on the pavement surface at regular intervals along long taxiways.

(e) Where applicable, the information marking shall be displayed across the taxiway or apron surface and shall be positioned to be legible from the approaching cockpit of the aircraft.

(f) When an information marking replaces or supplements a location sign, it shall consist of the following:

(1) a yellow inscription on a black background; and

(2) a black inscription on a yellow background when it replaces or supplements a direction or destination sign.

(g) When the contrast between the marking background and the pavement surface is insufficient, the marking shall include the following:

(1) a black border around the inscriptions in black; and

(2) a yellow border around the inscriptions in yellow.

(h) The height of the character shall be 4 metres. Inscriptions shall follow the format and proportions specified in Appendix C.

Note: Guidance on information marking is provided in OTAC 191-1.

Subpart K – Lights

191.179 General information

(a) A non-aeronautical ground light located near an aerodrome that poses a risk to aircraft safety shall be extinguished, screened, or otherwise modified to eliminate the source of danger.

(b) To safeguard aircraft against the hazardous effects of laser emitters, the following protected zones around aerodromes shall be established:

(1) a laser-beam free flight zone (LFFZ),

(2) a laser-beam critical flight zone (LCFZ),

(3) a laser-beam sensitive flight zone (LSFZ).

Note 1: The exposure levels and distances that adequately protect flight operations can be determined using Figures 19, 20, and 21.

Note 2: The prohibitions on using laser beams in the three designated protected flight zones, LFFZ, LCFZ, and LSFZ, apply only to visible laser beams. Authorities-operated laser emitters that are compatible with flight safety are excluded. In all navigable airspace, the irradiance level of any visible or invisible laser beam is expected to be less than or equal to the maximum permissible exposure (MPE) unless the Governor has been notified and permission obtained.

Note 3: The protected flight zones have been established to mitigate the risk of operating laser emitters near aerodromes.

Note 4: The Manual on Laser Emitters and Flight Safety (Doc 9815) provides additional advice on safeguarding flight operations from the potentially dangerous effects of laser emitters.

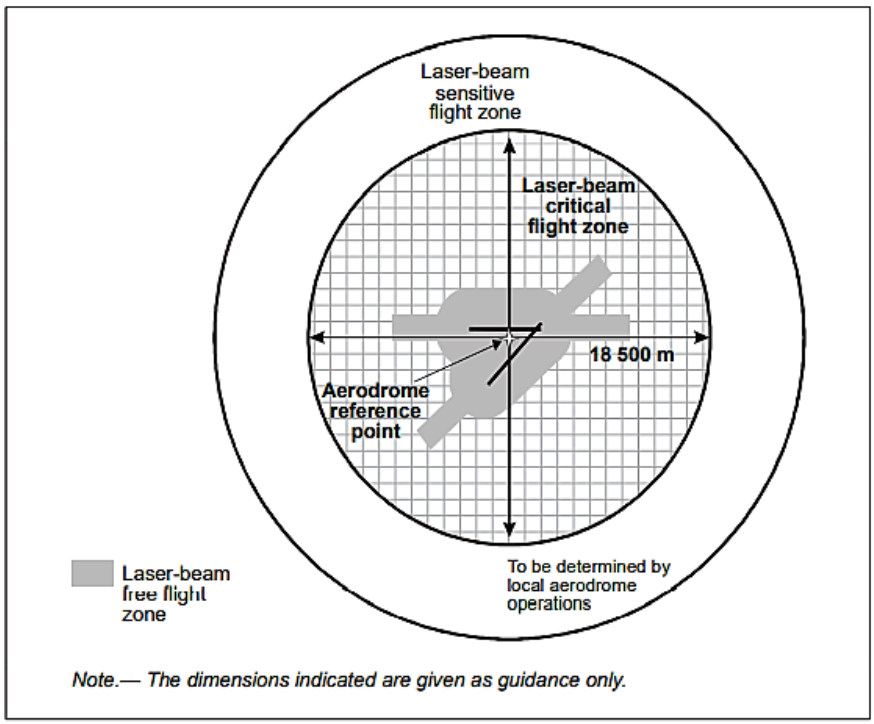
(c) A non-aeronautical ground light whose intensity, configuration, or colour may obstruct or confuse the clear interpretation of aeronautical ground lights shall be extinguished, screened, or otherwise modified to eliminate such a possibility. Attention shall be drawn in particular to the following nonaeronautical ground light visible from the air within the areas described below:

(1) Instrument runway — code number 4: located between the threshold and the end of the runway, extending at least 4 500 metres in length from the threshold to the end of the runway and 750 metres in width on either side of the extended runway centre line.

(2) Instrument runway — code number 2 or 3: as in OTAR 191.185 (c) (1), except that the runway shall be at least 3 000 metres long.

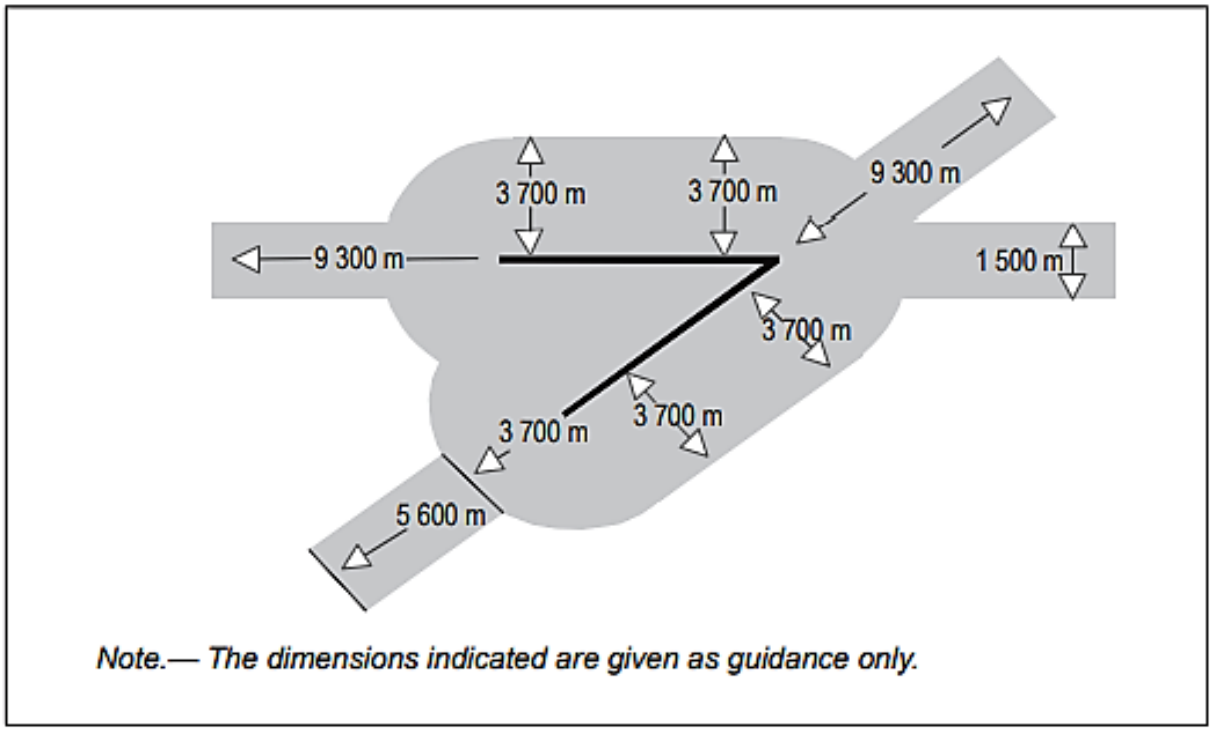
(3) Instrument runway — code 1; and non-instrument runway — located within the approach area.

Figure 19: Protected flight zones



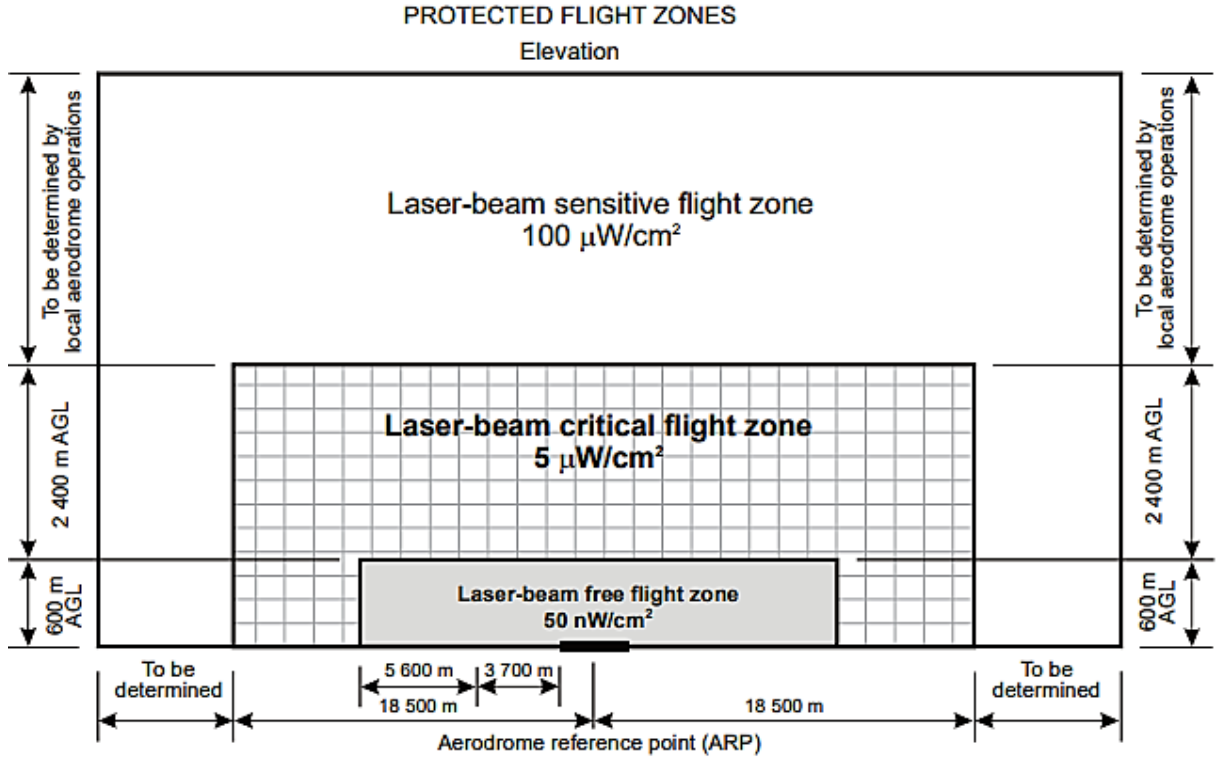
Source: ICAO Annex 14 Volume 1

Figure 20: Multiple runway laser-beam free flight zones



Source: ICAO Annex 14 Volume 1

Figure 21: Protected flight zones with an indication of maximum irradiance levels for visible laser beams



Source: ICAO Annex 14 Volume 1

(d) In the case of aeronautical ground lights near navigable waters, consideration shall be given to ensuring that the lights do not confuse mariners.

(e) Elevated approach lights and their supporting structures shall be frangible, except in the portion of the approach lighting system beyond 300 metres from the threshold:

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

(2) where non-frangible objects surround a supporting structure, only the portion of the structure that extends above the surrounding objects shall be frangible.

Note: For information on placing installations and equipment in operational areas, please refer to OTAR 191.321. For advice on the frangibility of lighting fixtures and supporting structures, please refer to Part 6 of the Aerodrome Design Manual (Doc 9157).

(f) When an approach light fixture or supporting structure is not sufficiently visible on its own, it shall be appropriately marked.

(g) Elevated runway lights, stopway lights, and taxiway lights shall be frangible. Their height shall be low enough to allow clearance for propellers and jet engine pods.

(h) Light fixtures embedded in the surface of runways, stopways, taxiways, and aprons shall be designed and installed so that they can withstand being run over by the wheels of an aircraft without causing damage to the aircraft or the lights themselves.

(i) During 10 minutes of exposure, the temperature generated by conduction or radiation at the interface between an installed inset light and an aircraft tyre shall not exceed 160°C.

Note: Guidance on measuring the temperature of inset lights is provided in the Aerodrome Design Manual (Doc 9157), Part 4

(j) Lighting can be more effective than marking at dusk or in low-visibility conditions during the day. To be effective in these conditions or low visibility at night, lights shall be of sufficient intensity. To achieve the desired intensity, it is frequently necessary to make the light directional. In this case, the arcs that the light shows span shall be adequate and oriented to meet operational requirements. The runway lighting system shall be viewed holistically to ensure that the relative light intensities are appropriately matched to the same purpose. (See OTAC 191-1)

(k) The intensity of runway lighting shall be sufficient to meet the minimum visibility and ambient light conditions required for runway use. It shall be compatible with the nearest section of the approach lighting system if provided.

Note: While the lights of an approach lighting system lights may be brighter than the runway lighting, it is best practice to avoid abrupt changes in intensity during the approach, as this may give the pilot the false impression that visibility is changing.

(l) Where a high-intensity lighting system is provided, an appropriate intensity control shall be incorporated to adjust the light intensity to match the prevailing conditions. Separate intensity controls or other suitable methods shall be provided to ensure that the following systems can operate at compatible intensities when installed:

(1) approach lighting system,

(2) runway edge lights,

(3) runway threshold lights,

(4) runway end lights,

(5) runway centre line lights,

(6) runway touchdown zone lights; and

(7) taxiway centre line lights.

(m) The maximum light intensity value on the perimeter of and within the ellipse defining the main beam in Appendix B, Figures APP.B-1 to APP.B-10 shall not be greater than three times the minimum light intensity value measured in accordance with Appendix B, notes for Figures APP.B-1 to APP.B-11 and APP.B-26.

(n) The maximum light intensity value on the perimeter of and within the rectangle defining the main beam in Appendix B, Figures APP.B-12 to APP.B-20 shall not be greater than three times the minimum light intensity value measured in accordance with Appendix B, notes for Figures APP.B-12 to APP.B-21.

191.181 Emergency lighting

(a) In the event that the normal lighting system fails at an aerodrome equipped with runway lighting and without a secondary power supply, sufficient emergency lights shall be readily available for installation on at least the primary runway.

Note: Emergency lighting can also be used to identify obstacles and delineate taxiways and apron areas.

(b) When installed on a runway, emergency lights shall meet the minimum requirements for a non-instrument runway configuration.

(c) The colour of the emergency lights shall conform to the colour requirements for runway lighting, except 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.

191.183 Aeronautical beacons

(a) Where operationally necessary, each aerodrome intended for night use shall have an aerodrome or identification beacon.

(b) The operational requirement shall be determined in accordance with the requirements of the air traffic that uses the aerodrome, the prominence of the features of the aerodrome in relation to their surroundings, and the installation of other visual and non-visual aids that aid in locating the aerodrome.

(c) Aerodrome beacon:

(1) An aerodrome intended for night use shall have an aerodrome beacon if one or more of the following conditions exists:

(i) aircraft navigate primarily visually,

(ii) reduced visibility is frequent; or

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

(2) The aerodrome beacon shall be located on or adjacent to the aerodrome in an area with minimal ambient lighting.

(3) The beacon shall be located so that it is not obscured by significant objects in significant directions and does not dazzle a pilot approaching land.

(4) The aerodrome beacon shall flash in alternating colours with white or all-white flashes.

(5) The total number of flashes per minute shall be between 20 and 30. Where beacons are used, the coloured flashes emitted at land aerodromes shall be green, and those at water aerodromes shall be yellow. If a combined water and land aerodrome is used, coloured flashes shall have the colour characteristics of the section of the aerodrome designated as the primary facility.

(6) The light of the beacon shall be visible from all azimuth angles. Vertical light distribution shall extend upward from a maximum elevation of 1° to an elevation determined by the appropriate authority to be sufficient to guide the maximum elevation for which the beacon is intended to be used, and the effective intensity of the flash shall not be less than 2 000 cd.

Note: In locations where excessive ambient background lighting cannot be avoided, the effective intensity of the flash may need to be increased by up to ten.

(d) Identification beacon:

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

(2) The identification beacon on the aerodrome shall be placed in an area with low ambient background lighting.

(3) The beacon shall be located so that it is not obscured by significant objects in significant directions and does not dazzle a pilot approaching land.

(4) An identification beacon at a land aerodrome shall be visible at all azimuth angles. The vertical light distribution shall extend upwards from no more than 1° to an elevation determined by the Governor to be sufficient to guide the maximum elevation at which the beacon is intended to be used, and the effective intensity of the flash shall be no less than 2 000 cd.

Note: In locations where excessive ambient background lighting cannot be avoided, the effective intensity of the flash may need to be increased by up to ten.

(5) At a land aerodrome, the identification beacon shall flash green; at a water aerodrome, the identification beacon shall flash yellow.

(6) International Morse Code shall be used to transmit the identification characters.

(7) The transmission speed shall be between six and eight words per minute, with the Morse dots lasting between 0.15 and 0.2 seconds per dot.

191.185 Approach lighting systems

(a) Where physically feasible, a simple approach lighting system as specified in OTAR 191.191 shall be provided to serve a non-instrument runway with a code number of 3 or 4 that is intended for night use, except when the runway is used only in good visibility, and other visual aids provide adequate guidance

Note: During the day, a simple approach lighting system can also serve as visual guidance.

(b) Where physically possible, a simple approach lighting system, as specified in OTAR 191.191, shall be provided to serve a non-precision approach runway, except when the runway is used only in good visibility or when other visual aids provide sufficient guidance.

Note: It is essential to consider installing a precision approach category I lighting system or adding a runway lead-in lighting system

(c) Where physically possible, a precision approach runway category I lighting system as specified in OTAR 193 shall be provided.

(d) A precision approach runway category II or III lighting system as specified in OTAR 191.195 shall be provided.

191.187 Simple approach lighting system

(a) A simple approach lighting system shall consist of a row of lights on the extended centre line of the runway extending, whenever possible, for at least 420 metres from the threshold and a row of lights forming a crossbar 18 metres or 30 metres in length at a distance of 300 metres from the threshold.

(b) The crossbar lights shall be arranged as closely as possible in a horizontal straight line perpendicular to and bisected by the line of the centre line lights. The lights of the crossbar shall be spaced linearly, except when a crossbar of 30 m is used; gaps may be left on either side of the centre line. To comply with local requirements, these gaps shall be kept to a minimum and shall not exceed 6 m in length.

Note 1: The crossbar lights are spaced between 1 and 4 metres apart. Gaps on either side of the centre line may improve directional guidance and facilitate the movement of rescue and firefighting vehicles when approaches are made with a lateral error.

Note 2: See OTAC 191-1 for guidance on installation tolerance

(c) The lights forming the centre line shall be spaced longitudinally at 60 m intervals, except that a 30 m interval may be used to improve guidance. The innermost light shall be 60 or 30 metres from the threshold, depending on the longitudinal interval chosen for the centre line lights.

(d) If a centre line extending 420 metres from the threshold is not physically possible, it shall be extended to 300 metres to include the crossbar. If this is not possible, the centre line lights shall be extended as far as possible, with each light consisting of a barrette measuring at least 3 metres. If the approach system includes a crossbar 300 metres from the threshold, an additional crossbar 150 metres from the threshold may be provided.

(e) The system shall be located as closely as possible in the horizontal plane passing through the threshold, provided that:

(1) no object other than an ILS or MLS azimuth antenna shall protrude through the plane of the approach lights within 60 metres of the centre line of the system; and

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

Any ILS or MLS azimuth antenna that protrudes through the plane of the lights shall be treated as an obstruction and appropriately marked and illuminated.

(f) The lights shall be fixed, and their colour shall be such that the system is readily distinguishable from other aeronautical ground lights and any additional lighting that may be present. Each centre-line light shall be composed of one of the following:

(1) a single source; or

(2) a barrette measuring at least 3 m in length.

Note 1: When the barrette described in OTAR 197.191 (f) (1) is composed of lights resembling point sources, a spacing of 1.5 m between adjacent lights is satisfactory.

Note 2: If it is anticipated that the simple approach lighting system will be developed into a precision approach lighting system, it may be prudent to use barrettes 4 m in length.

Note 3: In locations where identifying the simple approach lighting system at night is difficult due to ambient lighting, sequence flashing lights installed in the outer portion of the system may resolve this issue.

(g) On a non-instrument runway, the lights shall illuminate at all azimuth angles necessary for a pilot on the base leg and final approach. The intensity of the lights shall be sufficient for all visibility and ambient light conditions for which the system was designed.

(h) On a non-precision approach runway, the lights shall illuminate at all azimuth angles necessary to the pilot of an aircraft that does not deviate significantly from the path defined by the non-visual aid on the final approach. The lights shall be designed to guide during the day and at night in the most adverse conditions of visibility and ambient light in which the system is intended to function.

191.189 Precision approach category I lighting system

(a) A precision approach category I lighting system shall consist of a row of lights along the extended centre line of the runway extending, wherever possible, over a distance of 900 metres from the runway threshold, and a row of lights forming a 30-meter-long crossbar at a distance of 300 metres from the runway threshold

Note: The installation of an approach lighting system less than 900 metres in length may impose operational constraints on the use of the runway. See OTAC 191-1.

(b) The crossbar lights shall be arranged as closely as possible in a horizontal straight line perpendicular to and bisected by the line of the centre line lights. The lights of the crossbar shall be spaced linearly, except that gaps may be left on either side of the centre line. To comply with local requirements, these gaps shall be kept to a minimum and shall not exceed 6 m in length.

Note 1: The crossbar lights are spaced between 1 and 4 metres apart. Gaps on either side of the centre line may improve directional guidance and facilitate the movement of rescue and firefighting vehicles when approaches are made with a lateral error.

Note 2: See OTAC 191-1 for guidance on installation tolerances.

(c) The lights that comprise the centre line shall be spaced 30 metres apart longitudinally, with the innermost light 30 metres from the threshold.

(d) The system shall be located as closely as possible in the horizontal plane passing through the threshold, provided that:

(1) no object other than an ILS or MLS azimuth antenna shall protrude through the plane of the approach lights within 60 metres of the centre line of the system; and

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

Any ILS or MLS azimuth antenna that protrudes through the plane of the lights shall be treated as an obstruction and appropriately marked and illuminated.

(e) A centre line and crossbar lights shall be fixed lights with variable white. Each centre-line light position shall consist of one or more of the following:

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

(2) a barrette.

(f) Where the serviceability of the approach lights specified in OTAR 190.30 (c) can be demonstrated, each centre line light position may consist of either:

(1) a single light source; or

(2) a barrette.

(g) Barrettes shall be at least 4 metres in length. When barrettes are composed of lights that approximate point sources, the lights shall be uniformly spaced at no more than 1.5 m intervals.

(h) If the central line is made up of barrettes as described in OTAR 191.193 (e) (3) or OTAR 191.193 (f) (2), each barrette shall be accompanied by a flashing light, unless such lighting is deemed unnecessary in light of the characteristics of the system and the nature of the meteorological conditions.

(i) Each flashing light described in OTAR 191.193 (h) shall be flashed twice per second in the sequence, starting with the outermost light and progressing inward toward the threshold to the innermost light of the system. The electrical circuit shall be designed to operate these lights independently of the other lights of the approach lighting system.

(j) If the centre line is made up of lights as described in OTAR 191.193 (e) (1) or OTAR 191.193 (f) (1), additional crossbars of lights in addition to the crossbar provided at 300 metres from the threshold shall be provided at 150 metres, 450 metres, 600 metres, and 750 metres from the threshold. Each lights of the crossbar shall be arranged as nearly as possible in a horizontal straight line perpendicular to and bisected by the line of the centre line lights. The lights shall be spaced linearly, except that gaps may be left on either side of the centre line. To comply with local requirements, these gaps shall be kept to a minimum and shall not exceed 6 m in length.

Note: See OTAC 191-1 for detailed configuration.

(k) Where the system incorporates the additional crossbars described in OTAR 191.193 (j), the outer ends of the crossbars shall be parallel to the line of the centre line lights or converge to meet the runway centre line 300 metres from the threshold.

(l) The lights shall be in accordance with the specifications of Appendix B, Figure APP.B -1

Note: The flight path envelopes used in the design of these lights are given in OTAC 191-1.

191.191 Precision approach category I II and III lighting system

(a) The approach lighting system shall consist of a row of lights extending along the extended centre line of the runway for a distance of at least 900 metres from the runway threshold. Additionally, the system shall include two side rows of lights extending 270 metres from the threshold and two crossbars, one 150 metres from the threshold and one 300 metres from the threshold, as illustrated in Figure 22. Where the serviceability level of the approach lights specified in ICAO Annex 14 Volume 1 10.5.7 can be demonstrated, the system may consist of two side rows of lights extending 240 metres from the threshold and two crossbars, one 150 metres and one 300 metres from the threshold, as illustrated in Figure 23.

Note: The 900 m length is based on guiding operations in categories I, II, and III. Reduced lengths may support operations in categories II and III but may impose restrictions on operations in category I. See OTAC 191-1.

(b) The lights forming the centre line shall be spaced 30 metres apart longitudinally, with the innermost lights 30 metres from the threshold.

(c) The side rows of lights shall be placed on either side of the centre line, with the first light located 30 metres from the threshold and longitudinal spacing equal to that of the centre line lights. Where the serviceability of the approach lights specified in ICAO Annex 14 Volume 1 10.5.7 can be demonstrated, lights forming the side rows may be placed on either side of the centre line at a longitudinal spacing of 60 m, with the first light located 60 m from the threshold. The lateral spacing (or gauge) between the innermost lights of the side rows shall be not less than 18 m nor greater than 22.5 m, preferably 18 m, but in any case, equal to the threshold.

(d) At 150 metres from the threshold, the crossbar shall fill in the gaps between the centre line and side row lights.

(e) The crossbar located 300 metres from the threshold shall extend 15 metres on both sides of the centre line lights.

(f) If the centre line extends beyond 300 metres from the threshold, additional crossbars of lights as described in OTAR 191.195 (j) (2) or OTAR 191.195 (k) (2) shall be provided at 450 metres, 600 metres, and 750 metres from the threshold.

(g) Where the system incorporates the additional crossbars described in OTAR 191.195 (n), the outer ends of these crossbars shall be parallel to the runway centre line or converge to meet the runway centre line 300 metres from the threshold.

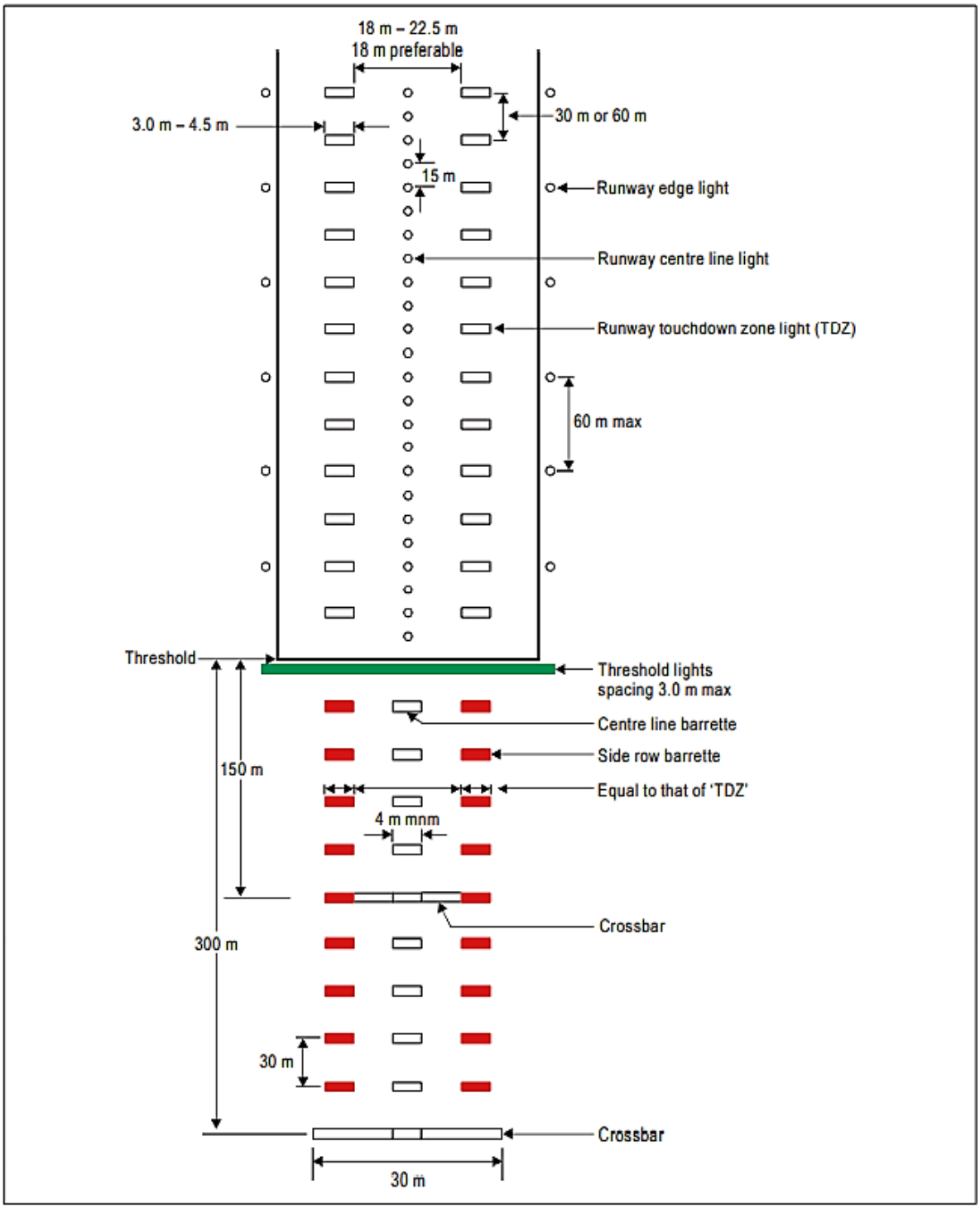
(h) The system shall be located as closely as possible in the horizontal plane passing through the threshold, provided that:

(1) no object other than an ILS or MLS azimuth antenna shall protrude through the plane of the approach lights within 60 metres of the centre line of the system; and

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

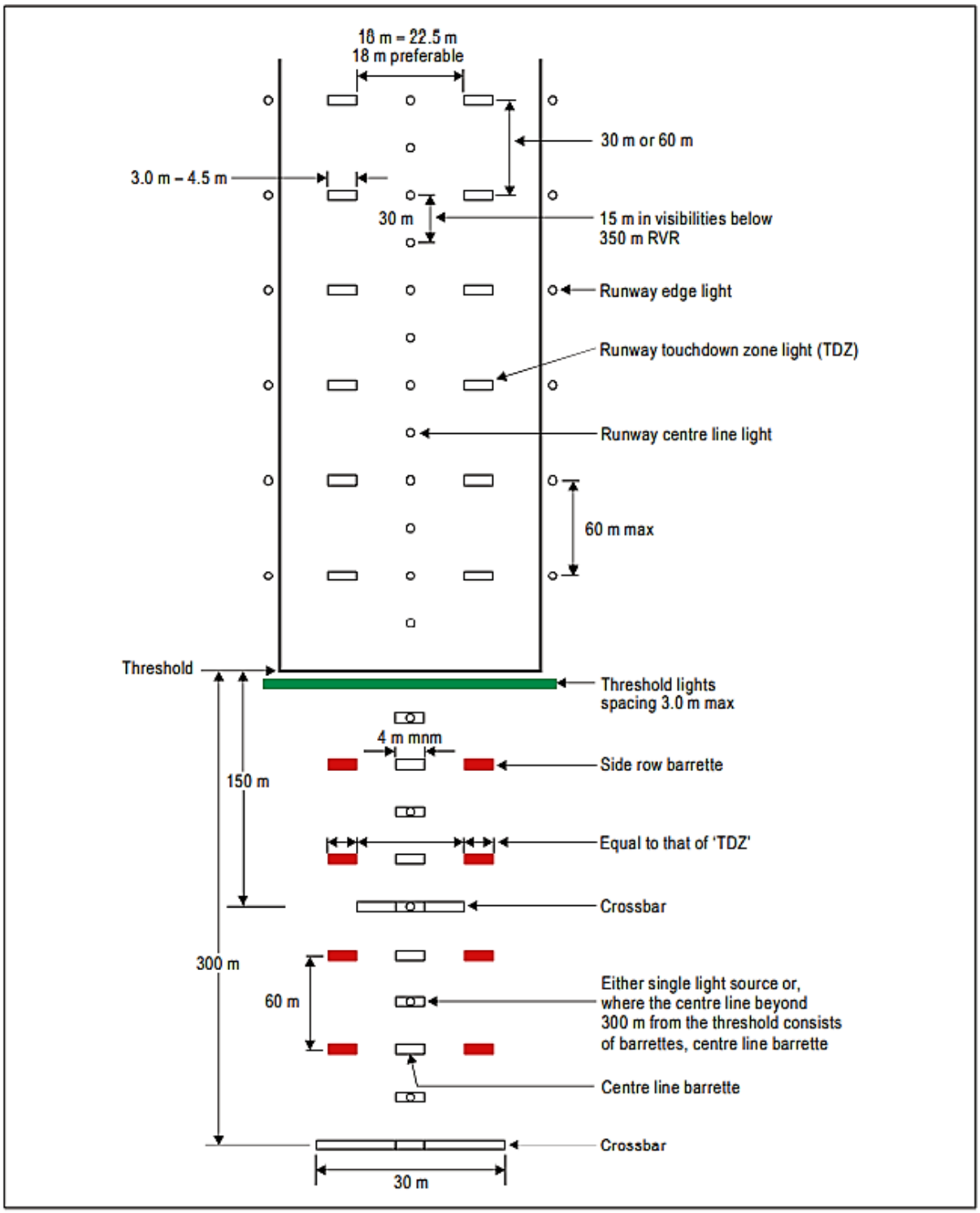
Any ILS or MLS azimuth antenna that protrudes through the plane of the lights shall be treated as an obstruction and appropriately marked and illuminated.

Figure 22: Inner 300 m approach and runway lighting for precision approach runways, categories II and III



Source: ICAO Annex 14 Volume 1

Figure 23: Inner 300 m approach and runway lighting for precision approach runways, categories II and III, where the serviceability levels of the lights specified as maintenance objectives in Chapter 10 can be demonstrated



Source: ICAO Annex 14 Volume 1

(i) The centre line of a precision approach category II or III lighting system shall consist of barrettes displaying variable white for the first 300 metres from the threshold, except that where the threshold is displaced by 300 metres or more, the centre line may consist of single light sources displaying variable white. Where the serviceability level of the approach lights specified in ICAO Annex 14 Volume 1 10.5.7 can be demonstrated, the centre line of a precision approach category II or III lighting system for the first 300 metres from the threshold may consist of either:

(1) barrettes, where the centre line beyond 300 m from the threshold consists of barrettes as described in OTAR 191.195 (k) (1); or

(2) alternate single light sources and barrettes, where the centre line beyond 300 m from the threshold consists of single light sources as described in OTAR 191.195 (k) (2), with the innermost single light source located 30 m and the innermost barrette located 60 m from the threshold; or

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

all of which shall show variable white.

(j) Beyond 300 metres from the threshold, each centre-line light position shall consist of either:

(1) a barrette similar to that used on the inner 300 metres; or

(2) two light sources in the central 300 metres and three light sources in the outer 300 metres,

all of which shall emit variable white light.

(k) Where the serviceability of the approach lights specified in ICAO Annex 14 Volume 1 10.5.7 can be demonstrated, each centre line light position beyond 300 metres from the threshold may consist of either:

(1) a barrette; or

(2) a single light source,

all of which shall display variable white light.

(l) Barrettes shall be at least 4 metres in length. When barrettes are composed of lights that approximate point sources, the lights shall be uniformly spaced at no more than 1.5 m intervals.

(m) If the centre line extends beyond 300 metres from the threshold in the manner described in OTAR 191.195 (j) (1) or OTAR 191.195 (k) (1), each barrette beyond 300 metres shall be supplemented by a flashing light, unless such lighting is deemed unnecessary in light of the characteristics of the system and the nature of the meteorological conditions.

(n) As defined in OTAR 191.195 (f), each flashing light shall be flashed twice per second in the sequence, beginning with the outermost light and progressing inward toward the threshold to the innermost light of the system. The electrical circuit shall be designed to operate these lights independently of other lights of the approach lighting system.

(o) The side row shall be composed of red barrettes. The length of a side row barrette and the spacing of its lights shall be equal to those of the TDZ light barrettes.

(p) The crossbars shall be illuminated by fixed lights that display a variable white. The lights shall be uniformly spaced at not more than 2.7 m intervals.

(q) The intensity of the red lights shall be compatible with the intensity of the white light.

(r) The lighting shall conform to the specifications outlined in Appendix B, Figures APP.B -1 and APP.B -2.

Note: The flight path envelopes used in the design of these lights are given in OTAC 191-1.

191.193 Visual approach slope indicator systems

(a) Where one or more of the following conditions exist, a visual approach slope indicator system shall be provided to serve the approach to a runway, regardless of whether other visual approach aids or non-visual aids serve the runway:

(1) the runway is used by turbojets or other aircraft with similar approach guidance requirements,

(2) the pilot of any type of aircraft may have difficulty judging the approach due to the following:

(i) insufficient visual guidance, such as that encountered during an approach over water or featureless terrain during the day, or in the absence of sufficient extraneous lighting in the approach area during the night; or

(ii) misleading information, such as that produced by deceptive surrounding terrain or runway markings.

(3) if an aeroplane descends below the normal approach path, the presence of objects in the approach area could pose a serious risk, especially if there are no non-visual or other visual aids to warn of such objects;

(4) if an aeroplane undershoots or overruns the runway, the physical conditions at either end of the runway pose a serious risk; and

(5) during the approach, the terrain or weather conditions may cause the aeroplane to experience unusual turbulence.

Note: Guidance on the priority of installation of visual approach slope indicator systems is contained in OTAC 191-1.

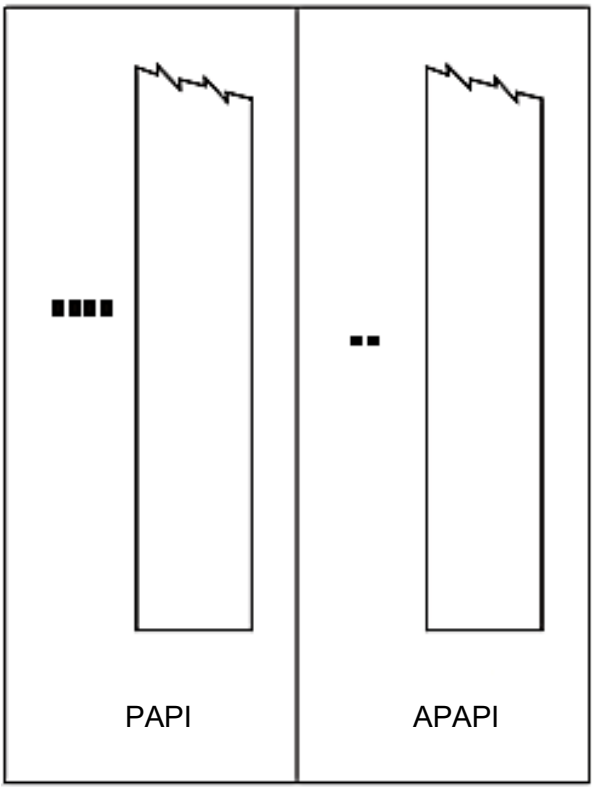
(b) The standard visual approach slope indicator systems shall consist of PAPI and APAPI systems conforming to the specifications contained in OTAR 191.197 (f) to OTAR 191.197 (dd) inclusive, as shown in Figure 23.

(c) PAPI shall be provided where the code number is 3 or 4 when one or more of the conditions specified in OTAR 191.823 (a) exists.

(d) PAPI or APAPI shall be provided where the code number is 1 or 2 when one or more of the conditions specified in OTAR 191.197 (a) exists.

(e) When a runway threshold is temporarily displaced from its normal position, and one or more of the conditions specified in OTAR 191.197 (a) exist, a PAPI shall be provided, except that an APAPI may be provided when the code number is 1 or 2.

Figure 24: Visual approach slope indicator systems



(f) The PAPI system shall comprise a wing bar containing four evenly spaced sharp transition multi-lamp (or paired single lamp) units. Unless it is physically impracticable, the system shall be located on the left side of the runway.

Note: Where a runway is used by aircraft that require visual roll guidance that cannot be provided by other external means, a second wing bar on the opposite side of the runway may be provided.

(g) The APAPI system shall comprise a wing bar of two sharp transition multi-lamp (or paired single lamp) units. Unless it is physically impracticable, the system shall be located on the left side of the runway.

Note: Where a runway is used by aircraft that require visual roll guidance that cannot be provided by other external means, a second wing bar on the opposite side of the runway may be provided.

(h) The wing bar of a PAPI shall be constructed and arranged in such a way that a pilot making an approach will see:

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

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

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

(i) The wing bar of a PAPI shall be constructed and arranged in such a way that a pilot making an approach will:

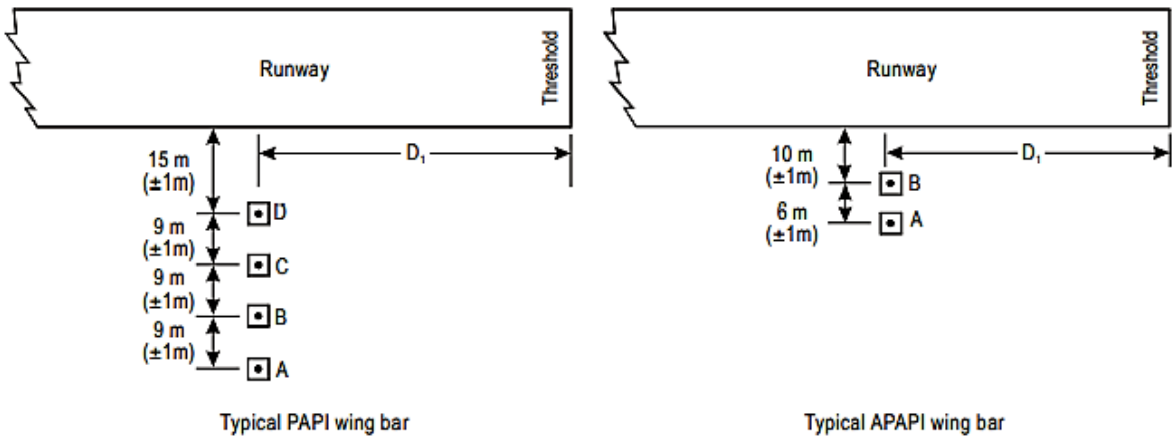
(1) when on or close to the approach slope, see the unit nearer the runway as red and the unit farther from the runway as white;

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

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

(j) The light units shall be installed in the basic configuration depicted in Figure 24, within the installation tolerances specified in OTAR 191.197 (k) to (q) inclusively. The light units shall be installed as low as possible and be frangible. The units forming a wing bar shall be mounted to appear substantially horizontal to the pilot of an approaching aeroplane.

Figure 25: Location of PAPI and APAPI



Source: ICAO Annex 14 Volume 1

(k) When a PAPI or APAPI is installed on a runway that does not have an ILS or MLS, the distance D_1 shall be calculated to ensure that the lowest height at which a pilot will see a correct approach path indication (Figure 26, angle B for a PAPI and angle A for an APAPI) provides wheel clearance above the threshold specified in Table 14 for the most demanding aeroplanes that use the runway regularly.

(l) Where a PAPI or APAPI is installed on a runway equipped with an ILS and/or MLS, the distance D_1 shall be calculated to ensure the best possible compatibility between the visual and non-visual aids for the range of eye-to-antenna heights of the aeroplanes that use the runway regularly. The distance between the threshold and the effective origin of the ILS glide path or MLS minimum glide path, as applicable, shall be equal to the distance between the threshold and the effective origin of the ILS glide path or MLS minimum glide path, plus a correction factor for the variation in the eye-to-antenna heights of the aeroplanes concerned. The correction factor is calculated by multiplying the average eye-to-antenna height of the aircraft by the approach the cotangent of the angle. The distance, however, shall be such that the wheel clearance over the threshold is never less than that specified in Table 14.

Note: Specifications for aiming point marking can be found in OTAR 191.153. OTAC 191-1 provides instructions on harmonising PAPI, ILS, and/or MLS signals.

(m) If a greater wheel clearance than specified in OTAR 191.197 (k) is required for a particular aircraft, it can be obtained by increasing D_1.

(n) Adjustment of distance D_1 is required to account for elevation differences between the lens centres of the light units and the threshold.

(o) Small height adjustments of up to 5 cm between units are acceptable to accommodate any transverse slope and ensure that units are mounted as low as possible. A lateral gradient of no more than 1.25 per cent is acceptable as long as it is applied uniformly across the units.

(p) Code numbers 1 and 2 shall use a spacing of 6 m (±1 m) between PAPI units. In this case, the inner PAPI unit shall be located no less than ten metres (±1 m) from the runway edge.

Note: Reducing the spacing between light units reduces the usable range of the system.

(q) If a greater range is required or a later conversion to a full PAPI is anticipated, the lateral spacing between APAPI units may be increased to 9 m (±1 m). The latter case requires that the inner APAPI unit be located 15 metres (±1 m) from the runway edge.

(r) The system shall operate both during the day and at night.

(s) The vertical colour transition from red to white shall be such that an observer standing at a distance of not less than 300 metres perceives it to occur within a vertical angle of not more than 3.

(t) The Y coordinate of the red light at maximum intensity shall not exceed 0.320.

(u) The light intensity distribution in the light units shall be as illustrated in Appendix B, Figure APP.B-23.

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

(v) Appropriate intensity control shall be provided to adjust to changing conditions and avoid blinding the pilot during the approach and landing.

(w) Each light unit shall be adjustable in elevation so that the lower limit of the white portion of the beam may be fixed at any angle between 1°30 and at least 4°30 above the horizontal.

(x) The light units shall be designed in such a way that deposits of condensation, snow, ice, or dirt on optically transmitting or reflecting surfaces interfere with the light signals to the least extent possible and do not affect the contrast between red and white signals or the elevation of the transition sector.

(y) The approach slope defined in Figure 26 shall be suitable for use by the aeroplanes that use the approach.

(z) When the runway is equipped with an ILS and/or MLS, the location and angle of elevation of the light units shall be such that the visual approach slope closely matches the ILS glide path and/or the MLS minimum glide path, as applicable.

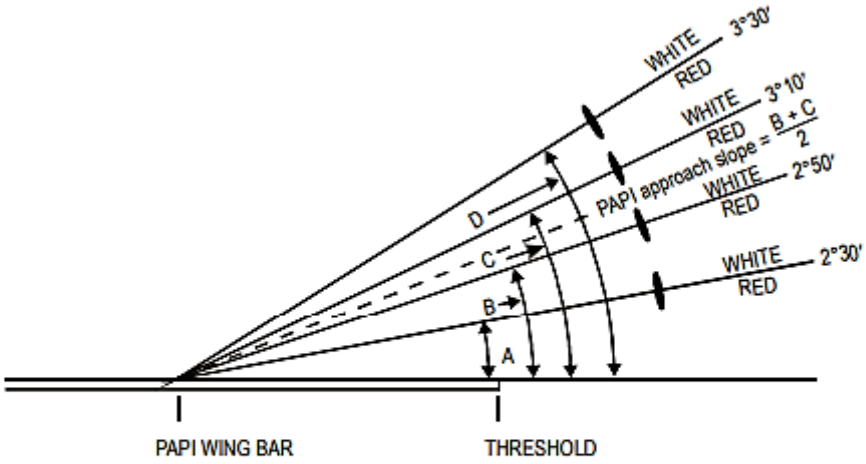
(aa) The angle of elevation settings for the light units in a PAPI wing bar shall be such that the pilot of an aeroplane observing a signal of one white and three reds will clear all objects in the approach area by a safe margin during an approach (see Table 14).

(bb) The angle of elevation settings for the light units in an APAPI wing bar shall be such that the pilot of an aeroplane observing the lowest on-slope signal, i.e., one white and one red, will clear all objects in the approach area by a safe margin during an approach (see Table 14).

(cc) The azimuth spread of the light beam shall be appropriately restricted when an object located outside the obstacle protection surface of the PAPI or APAPI system but within the lateral limits of its light beam is discovered to extend above the plane of the obstacle protection surface, and an aeronautical study indicates that the object could adversely impact operational safety. The restriction shall be sufficient to keep the object outside the confines of the light beam.

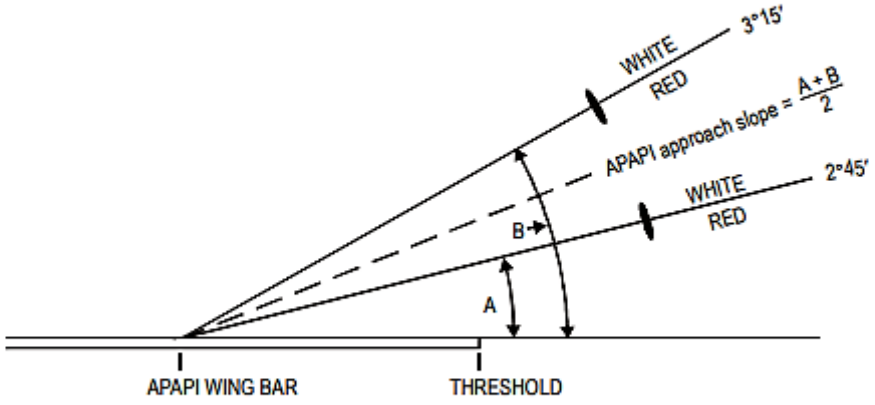
Note: See OTAR 191.197 (ee) regarding the related obstacle protection surface.

Figure 26: Light beams and angle of elevation setting of PAPI and APAPI



The height of the pilot's eye above the ILS glide path/MLS antenna of the aircraft varies with the type of aeroplane and approach attitude. Harmonization of the PAPI signal and ILS glide path and/or MLS minimum glide path to a point closer to the threshold may be achieved by increasing the on-course sector from 20 to 30. The setting angles for a 3° glide slope would then be 2°25, 2°45, 3°15 and 3°35.

A — 3° PAPI ILLUSTRATED



B — 3° APAPI ILLUSTRATED

Source: ICAO Annex 14 Volume 1

Table 14: Wheel clearance over threshold for PAPI and APAPI

Eye-to-wheel height of aeroplane in the approach configuration[a]	Desired wheel clearance (metres)[b,c]	Minimum wheel clearance (metres)[d]
up to but not including 3 m	6	3[e]
3 m up to but not including 5 m	9	4
5 m up to but not including 8 m	9	5
8 m up to but not including 14 m	9	6

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

(dd) Where the wing bars are installed on either side of the runway to provide roll guidance, corresponding units shall be set at the same angle to ensure that the signals from each wing bar change symmetrically simultaneously.

(ee) An obstacle protection surface shall be established when it is intended to provide a visual approach slope indicator system.

(ff) The origin, divergence, length, and slope of the obstacle protection surface shall correspond to those specified in the relevant column of Table 15 and Figure 27.

(gg) No new objects or extensions of existing objects shall be permitted above an obstacle protection surface unless the new object or extension is shielded by an existing immovable object, in the opinion of the Governor.

Note: Circumstances in which the shielding principle may reasonably be applied are described in OTAC 191-1.

(hh) Existing objects above an obstacle protection surface shall be removed unless an existing immovable object shields the object or an aeronautical study determines that the object would not jeopardise the safety of aeroplane operations.

(ii) Where an aeronautical study indicates that an existing object extending above an obstacle protection surface (OPS) may adversely impact the safety of aircraft operations, one or more of the following shall be taken:

(1) remove the object,

(2) appropriately increase the approach slope of the system,

(3) appropriately decrease the azimuth spread of the system so that the object is outside the confines of the beam,

(4) appropriately shift the axis of the system and associated obstacle protection surface by no more than 5°; and

(5) appropriately shift the system upwind of the threshold so that the object no longer penetrates the OPS.

Note 1: The displacement of the system upwind of the threshold reduces the operational landing distance.

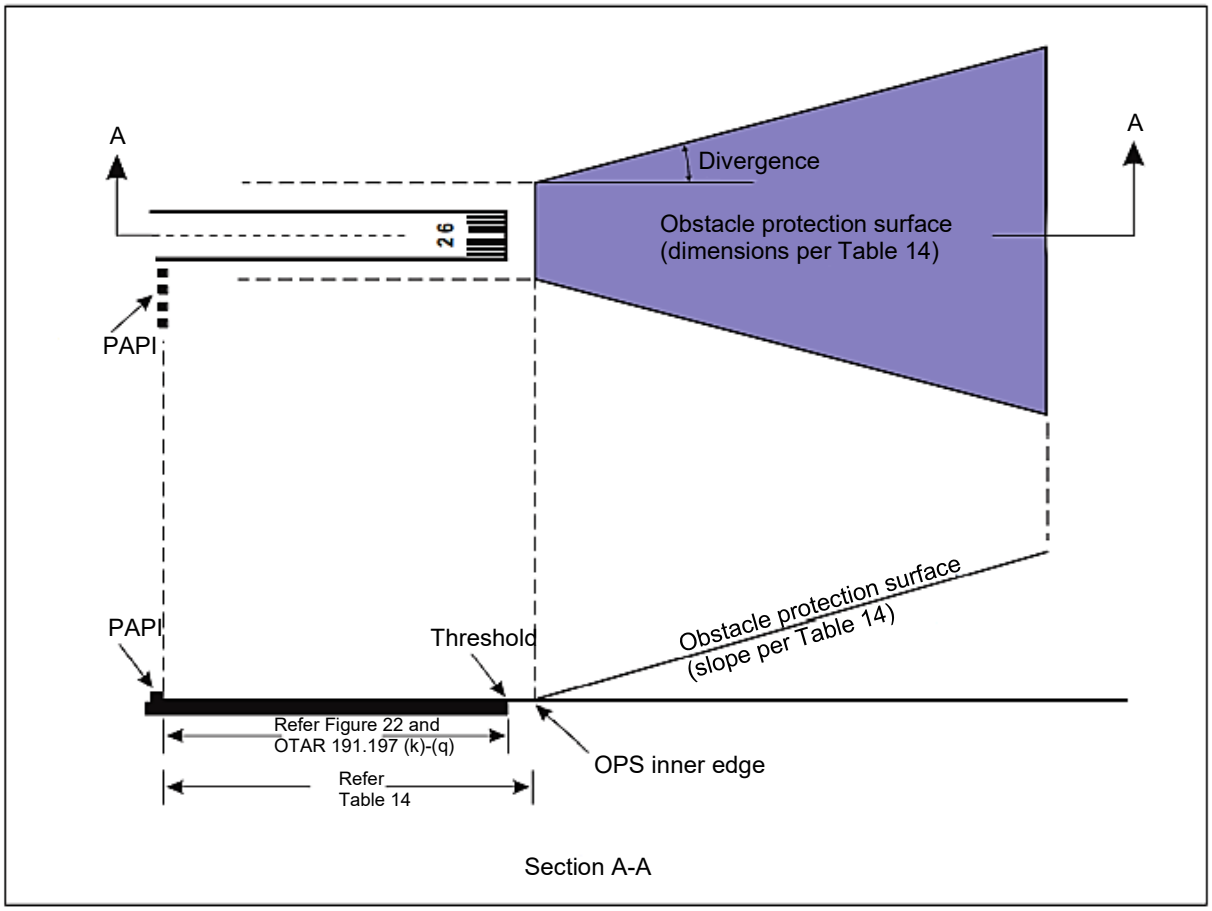
Note 2: Guidance on this issue is contained in OTAC 191-1.

Table 14: Dimensions and slopes of the obstacle protection surface

	Runway type/code number							
	Non-instrument Code number				Instrument Code number			
Surface dimensions	1	2	3	4	1	2	3	4
Length of the inner edge	60 m	80 m	150 m	150 m	150 m	150 m	300 m	300 m
Distance from the visual approach slope indicator system[b]	D_1+30 m	D_1+60 m	D_1+60 m	D_1+60 m	D_1+60 m	D_1+60 m	D_1+60 m	D_1+60 m
Divergence (each side)	10%	10%	10%	10%	15%	15%	15%	15%
Total length	7 500 m	7 500 m	15 000 m	15 000 m	7 500 m	7 500 m	15 000 m	15 000 m
Slope								
a) PAPI[a]	–	A–0.57°	A–0.57°	A–0.57°	A–0.57°	A–0.57°	A–0.57°	A–0.57°
c) APAPI[a]	A–0.9°	A–0.9°	–	–	A–0.9°	A–0.9°	–	–

[a.] Angles as indicated in Figure 26.
[b.] D_1 is the distance of the visual approach slope indicator system from the threshold prior to any displacement to remedy object penetration of the OPS (refer to Figure 23). The start of the OPS is fixed to the visual approach slope indicator system location, such that displacement of the PAPI results in an equal displacement of the start of the OPS. See OTAR 191.197 (ii) (5)).

Figure 27: Obstacle protection surface for visual approach slope indicator systems



Source: ICAO Annex 14 Volume 1

191.195 Circling guidance lights

(a) Circling guidance lights shall be provided when existing approach and runway lighting systems do not adequately identify the runway and/or approach area to a circling aircraft under the conditions intended for circling approaches.

(b) The location and number of circling guidance lights shall be sufficient to enable a pilot to:

(1) join the downwind leg or align and adjust the track of the aircraft to the runway at the required distance and to distinguish the threshold in passing; and

(2) maintain sight of the runway threshold and/or other features that will enable the pilot to judge the turn onto the base leg and final approach, taking into account the guidance provided by other visual aids.

(c) Circling guidance lights shall include the following:

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

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

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

(4) lights indicating the direction or location of the runway,

or a combination of these lights as appropriate for the runway under consideration.

Note: Guidance on installing circling guidance lights is provided in OTAC 191-1.

(d) Circling guidance lights shall be either fixed or flashing lights with intensity and beam spread appropriate for the visibility and ambient light conditions under which visual circling approaches are intended. White light shall be used for flashing lights, and white or gaseous discharge lights for steady lights.

(e) The lights shall be designed and installed so that they do not dazzle or confuse the pilot as they approach the runway, take off, or taxi.

191.197 Runway lead-in lighting systems

(a) A runway lead-in lighting system shall be installed where visual guidance along a specific approach path is desired, for example, to avoid hazardous terrain or to reduce noise.

Note: Guidance on providing lead-in lighting systems is provided in OTAC 191-1.

(b) A runway lead-in lighting system shall be composed of groups of lights arranged to define the desired approach path and allow for the sighting of one group from the preceding group. Between adjacent groups, the distance shall not exceed approximately 1 600 m.

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

(c) A runway lead-in lighting system shall extend from a point determined by the appropriate authority to a point given the approach lighting system, if provided, or the runway or runway lighting system.

(d) Each group of lights in a runway lead-in lighting system shall have at least three flashing lights arranged linearly or in clusters. The system may be supplemented with steady-burning lights in areas that aid system identification.

(e) The flashing lights and the steady burning lights shall be white.

(f) Wherever possible, the flashing lights in each group shall be directed toward the runway in sequence.

191.199 Runway threshold identification lights

(a) Runway threshold identification lights shall be installed:

(1) at the threshold of a non-precision approach runway when additional threshold conspicuity is required or when other approach lighting aids are not feasible: and

(2) where a runway threshold is permanently displaced from the runway extremity or temporarily displaced from its normal position, and additional threshold conspicuity is required.

(b) Runway threshold identification lights shall be symmetrically located along the runway centre line, parallel to the threshold, and approximately 10 metres beyond each line of runway edge lights.

(c) The identification lights at the runway threshold shall be flashing white lights with a flash frequency between 60 and 120 times per minute.

(d) The lights shall be visible only from the approach direction of the runway.

191.201 Runway edge lights

(a) Runway edge lights shall be provided on runways intended for night use or precision approach runways intended for day or night use.

(b) Runway edge lighting shall be provided on runways intended for take-off with an operating minimum of less than 800 m RVR during the day.

(c) Runway edge lights shall be installed parallel to the length of the runway and equidistant from the centre line in two parallel rows.

(d) Runway edge lights shall be installed at a distance of not more than 3 metres along the perimeter of the area designated for use as the runway or outside the perimeter of the area.

(e) Where the width of the area that could be designated as a runway exceeds 60 metres, the distance between the rows of lights shall be determined by the nature of the operations, the light distribution characteristics of the runway edge lights, and other visual aids serving the runway.

(f) The lights shall be uniformly spaced in rows at no more than 60 metres apart for instrument runways and at no more than 100 metres apart for non-instrument runways. The lights on either side of the runway axis shall be parallel to that axis. At runway intersections, lights may be spaced irregularly or omitted entirely as long as the pilot retains adequate guidance.

(g) Runway edge lights shall be fixed lights with variable white illumination, except that:

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

(2) a section of the lights 600 metres or one-third of the runway length, whichever is less, from the end of the runway where the take-off run begins may illuminate yellow.

(h) The runway edge lights shall be visible from all azimuth angles necessary to guide a pilot landing or taking off in either direction. When runway edge lights are used to provide circling guidance, they shall be visible at all azimuth angles (see OTAR 191.205 (a) and (b)).

(i) At all azimuths specified in OTAR 191.205 (h), runway edge lights shall be visible at an angle of up to 15° above the horizontal and with an intensity appropriate for the visibility and ambient light conditions under which the runway is intended to be used for take-off or landing. In all cases, the intensity of the lights shall be at least 50 cd, except that at an aerodrome without additional lighting, the intensity of the lights may be reduced to no less than 25 cd to avoid dazzling the pilot.

(j) On a precision approach runway, the runway edge lights shall conform to the specifications in Appendix B, Figure APP.B-9 or APP.B-10.

191.203 Runway threshold lights

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

(b) When a threshold is located at the extremity of the runway, the threshold lights shall be arranged in a row perpendicular to the runway axis as close to the extremity of the runway as possible and no more than 3 m outside the extremity in any case.

(c) When the extremity of a runway is displaced, a row of threshold lights at right angles to the runway axis shall be installed at the displaced threshold.

(d) On a non-instrument or non-precision approach runway, the threshold lighting shall consist of the following:

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

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

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

(e) The lights specified in OTAR 191.207 (d) (1) and (2) shall be:

(1) evenly spaced between the rows of runway edge lights; or

(2) symmetrically arranged around the runway centre line in two groups, with lights uniformly spaced within each group and a gap between the groups equal to the gauge of the touchdown zone marking or lighting, if provided, or not more than half the distance between the rows of runway edge lights.

191.205 Wing bar lights

(a) Wing bar lights shall be installed when additional visibility is required on a precision approach runway.

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

(c) At the threshold, wing bar lights shall be symmetrically distributed in two groups around the runway centre line, i.e. wing bars. Each wing bar shall be composed of at least five lights extending at least ten metres outward from and perpendicular to the line of the runway edge lights, with the innermost light of each wing bar aligned with the runway edge lights.

(d) Runway threshold and wing bar lights shall be permanently installed as unidirectional lights that illuminate green in the direction of the runway approach. The intensity of the light and beam spread shall be adequate for the visibility and ambient light conditions under which the runway is intended to be used.

(e) On a precision approach runway, the runway threshold lights shall be in accordance with the specifications in Appendix B, Figure APP.B-3.

(f) On a precision approach runway, the threshold wing bar lights shall conform to the specifications in Appendix B, Figure APP.B-4.

191.207 Runway end lights

(a) A runway equipped with runway edge lights shall have runway end lights.

Note: When the threshold is located at the extreme end of the runway, fittings normally used for threshold lighting may be used as runway end lights.

(b) Runway end lights shall be installed on a line perpendicular to the runway axis as close to the end of the runway as possible and no more than 3 metres outside the end.

(c) At least six lights shall be used to illuminate the runway ends. The lights shall be either:

(1) evenly spaced between the rows of runway edge lights; or

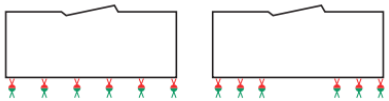
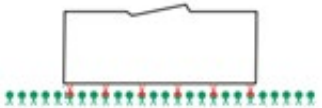
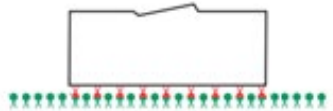
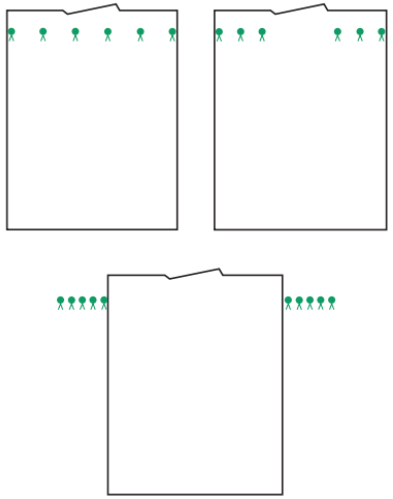
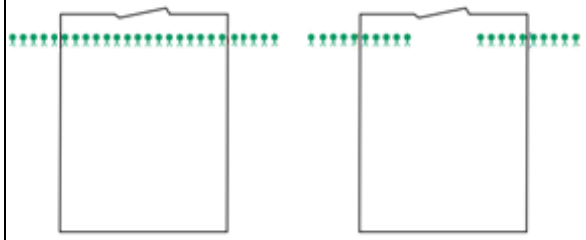
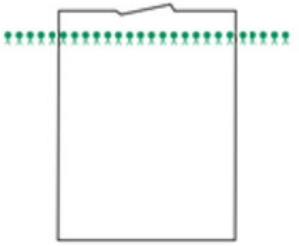
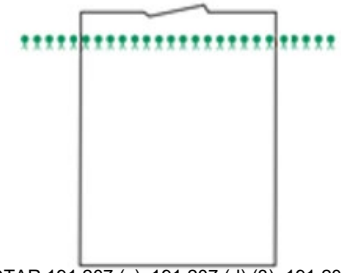
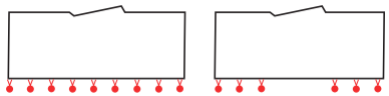
(2) symmetrically arranged around the runway centre line in two groups, with the lights uniformly spaced within each group and a gap between the groups equal to or greater than half the distance between the rows of runway edge lights.

(d) For a precision approach runway category III the spacing between runway end lights, except between the two innermost lights if a gap is used, shall not exceed 6 metres.

(e) Runway end lights shall be fixed unidirectional lights that illuminate red in the direction of the runway. The intensity of the light and beam spread shall be adequate for the visibility and ambient light conditions under which the runway is intended to be used.

(f) On a precision approach runway, the runway end lights shall conform to the specifications in Appendix B, Figure APP.B-8.

Figure 28: Arrangement of runway threshold and runway end lights

CONDITION	LIGHTS	RUNWAY TYPE			
		NON-INSTRUMENT AND NON-PRECISION APPROACH RUNWAYS	PRECISION APPROACH RUNWAYS CATEGORY I	PRECISION APPROACH RUNWAYS CATEGORY II	PRECISION APPROACH RUNWAYS CATEGORY III
THRESHOLD AT RUNWAY EXTREMITY	RUNWAY THRESHOLD AND RUNWAY END LIGHTS	 OTAR 191.207 (b), 191.207 (d) (1), 191.207 (e), 191.211 (b), (c), (d)	 OTAR 191.207 (b), 191.207 (d) (2), 191.207 (e), 191.211 (b), (c), (d)	 OTAR 191.207 (b), 191.207 (d) (3), 191.209 (c), 191.211 (b), (c), (d)	 OTAR 191.207 (b), 191.207 (d) (3), 191.209 (c), 191.211 (b), (c), (d)
THRESHOLD DISPLACED FROM RUNWAY EXTREMITY	RUNWAY THRESHOLD LIGHTS	 OTAR 191.207 (c), 191.207 (d) (1), 191.207 (e), 191.209 (c)	 OTAR 191.207 (c), 191.207 (d) (2), 191.207 (e), 191.209 (c)	 OTAR 191.207 (c), 191.207 (d) (3), 191.207 (e), 191.209 (c)	 OTAR 191.207 (c), 191.207 (d) (3), 191.207 (e), 191.209 (c)
	RUNWAY END LIGHTS	 OTAR 191.211 (b), (c), (d)			 OTAR 191.211 (b), (c), (d)

LEGEND
UNIDIRECTIONAL LIGHT

BIDIRECTIONAL LIGHT

Note: The minimum number of lights are shown for a runway 45 m wide with runway edge lights installed at the edge.

Source: ICAO Annex 14 Volume 1

191.209 Runway centre line lights

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

(b) Runway centre line lights shall be installed on precision approach runways classified as category I, especially when the runway is used by aircraft capable of high landing speeds or when the distance between the runway edge lights exceeds 50 metres.

(c) Runway centre line lights shall be provided on runways intended for take-off with an operating minimum of less than 400 m RVR.

(d) Runway centre line lights shall be provided on runways intended for take-off with an operating minimum RVR of 400 metres or greater when used by aircraft capable of very high take-off speeds, particularly where the width between the runway edge lights exceeds 50 metres.

(e) Runway centre line lights shall be located parallel to the runway centre line, except that they may be uniformly offset to the same side of the runway centre line by no more than 60 cm if it is impractical to locate them parallel to the runway centre line. The lights shall be spaced approximately 15 metres apart longitudinally from the threshold to the end. Where the serviceability of the runway centre line lights specified in ICAO Annex 14 Volume I 10.5.7 or 10.5.11 can be demonstrated, and the runway is intended for use in RVR of 350 metres or greater, the longitudinal spacing may be approximately 30 metres.

Note: Existing centre line lighting with 7.5 m spacing does not need to be replaced.

(f) Centre line guidance for take-off from the start of a runway to a displaced threshold shall be provided by:

(1) an approach lighting system if its characteristics and intensity settings provide the necessary guidance during take-off and do not dazzle the pilot of an aircraft taking off; or

(2) runway centre line lights; or

(3) barrettes of at least 3 m in length and spaced at uniform intervals of 30 m, as shown in Figure 29, and 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.

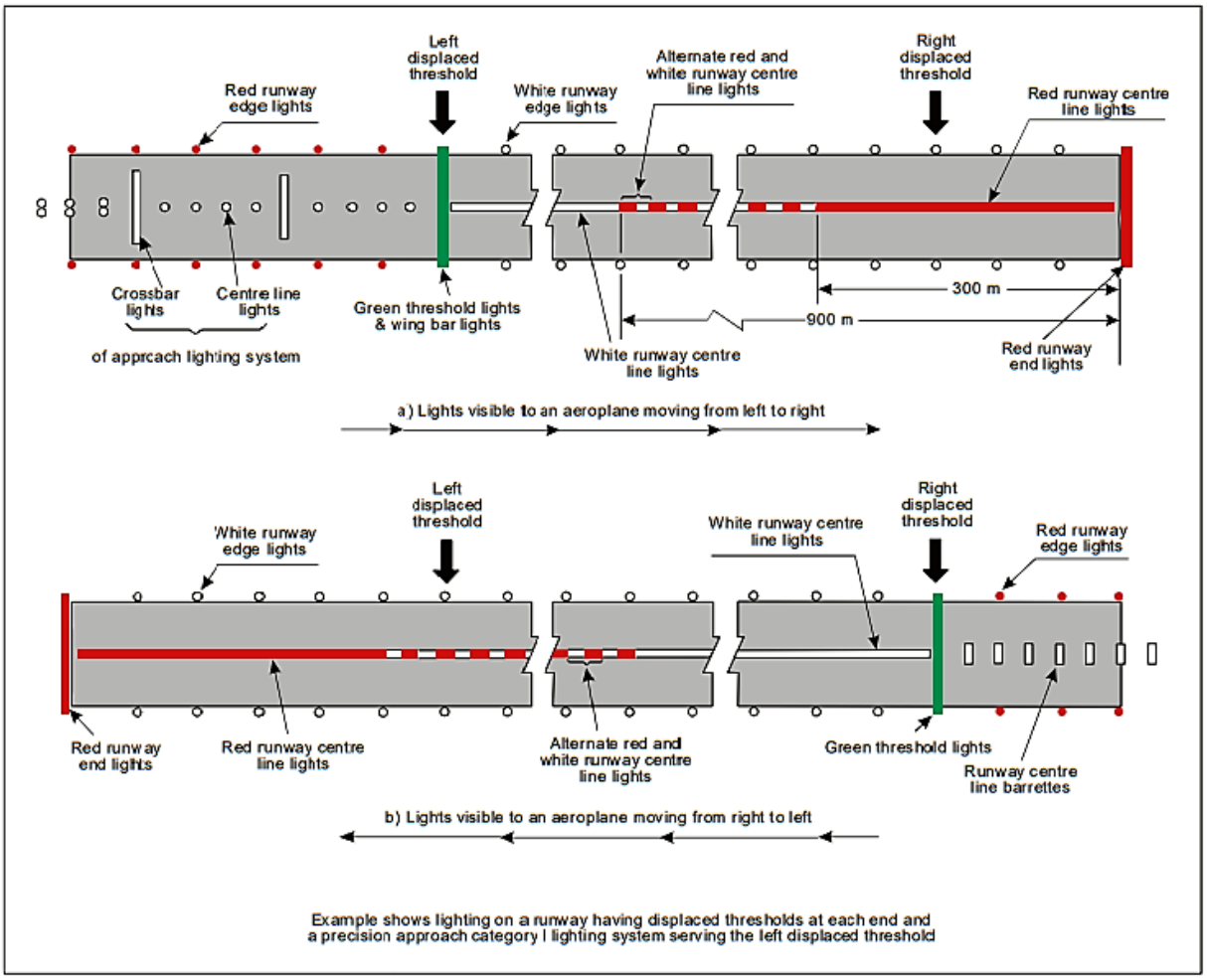
(g) When the runway is being used for landing, provisions shall be made to extinguish those centre line lights specified in OTAR 191.213 (f) (2) or to reset the intensity of the approach lighting system or barrettes. When the runway is being used for landing, only the single source runway centre line lights shall be illuminated from the start of the runway to a displaced threshold.

(h) Runway centre line lights shall be fixed lights that alternate between red and variable white from the threshold to 900 metres from the runway end, alternate between red and variable white from 900 metres to 300 metres from the runway end, and red from 300 metres to the runway end. The alternate red and variable white lights shall extend from the midpoint of the runway usable for landing to 300 metres from the runway end, except for runways less than 1800 metres in length.

Note: The electrical system must be designed with care to ensure that the failure of any component of the electrical system does not result in a false indication of the runway distance remaining.

(i) The runway centre line lights shall conform to the specifications outlined in Appendix B, Figure APP.B-6 or APP.B-7.

Figure 29: Example of approach and runway lighting for runway with displaced thresholds



So

Source: ICAO Annex 14 Volume 1

191.211 Runway touchdown zone lights

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

(b) TDZ lights shall extend longitudinally for a distance of 900 metres from the threshold, except that on runways less than 1800 metres in length, the system shall be shortened so that it does not extend beyond the midpoint of the runway. Pairs of barrettes symmetrically spaced around the runway centre line shall form the pattern. The lateral spacing between a pair of innermost lights of the barrettes shall equal the lateral spacing chosen for the touchdown zone marking. Between pairs of barrettes, the longitudinal spacing shall be either 30 m or 60 m.

Note: It may be reasonable to use a 30 m longitudinal spacing between barrettes to allow for operations at lower visibility minima.

(c) A barrette shall consist of at least three lights separated by no more than 1.5 m.

(d) A barrette shall be between 3 and 4.5 metres in length.

(e) The lights in the TDZ shall be fixed unidirectional lights that display a variable white.

(f) TDZ lighting shall conform to the specifications outlined in Appendix B, Figure APP.B-5.

191.213 Touchdown zone lights

(a) Unless TDZ lights are provided in accordance with OTAR 191.217, simple TDZ lights shall be provided at an aerodrome where the approach angle is greater than 3.5 degrees and/or the Landing Distance Available, when combined with other factors, increases the risk of an overrun.

(b) Simple TDZ lights shall consist of a pair of lights located 0.3 m beyond the upwind edge of the final TDZ marking each side of the runway centre line. The lateral spacing between the inner lights of the two pairs of lights shall be equal to the lateral spacing selected for the TDZ marking. The spacing between the lights of the same pair shall not be more than 1.5 m or half the width of the TDZ marking, whichever is greater. (For more information, see Figure 30).

(c) Where TDZ markings are not provided on a runway, simple TDZ lights shall be installed in a position that provides equivalent TDZ information.

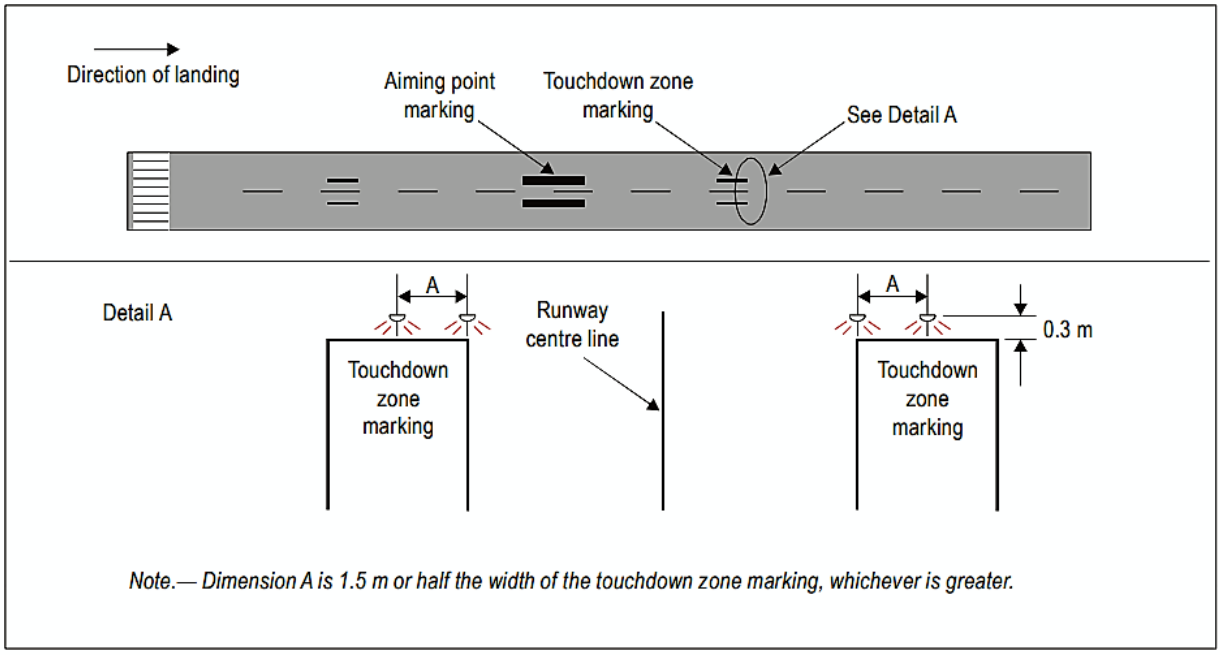
(d) Simple TDZ shall be fixed unidirectional lights that emit variable white light and are aligned in such a way that they are visible to the pilot of a landing aircraft in the direction of approach to the runway.

(e) Simple TDZ lights shall conform to the specifications outlined in Appendix B, Figure APP.B-5.

Note 1: As a best practise, simple TDZ lights are powered separately from another runway lighting, allowing them to be used when another lighting is turned off.

Note 2: Simple TDZ lights are intended to improve pilot situational awareness in all visibility conditions and to assist pilots in determining whether to initiate a go-around if the aircraft has not landed by a specified point on the runway. It is critical for pilots operating at aerodromes equipped with simple TDZ lights to understand their function.

Figure 30: Simple touchdown zone lighting



Source: ICAO Annex 14 Volume 1

191.215 Rapid exit taxiway indicator lights

(a) Rapid exit taxiway indicator lights (RETILs) shall be provided on runways intended for use when the RVR is less than 350 metres and/or when the traffic density is high.

(b) RETILs are a group of yellow unidirectional lights installed on the runway near the centre line. They are designed to alert pilots to the location of the next available RET. The lights are spaced 100 metres apart in a 3-2-1 pattern before the point of tangency of the rapid exit taxiway centre line.

Note: For further guidance, refer to OTAC 191-1.

(c) RETILs shall not be displayed if any lamp fails or if any other failure prevents the full display of the light pattern depicted in Figure 31.

(d) A set of RETILs shall be located on the runway, on the same side of the runway centre line as the associated RET, in the configuration depicted in Figure 31. Each set shall consist of two lights separated by two metres, with the light closest to the runway centre line displaced by two metres.

(e) Where a runway has more than one RET, the set of RETILs for each exit shall be displayed separately.

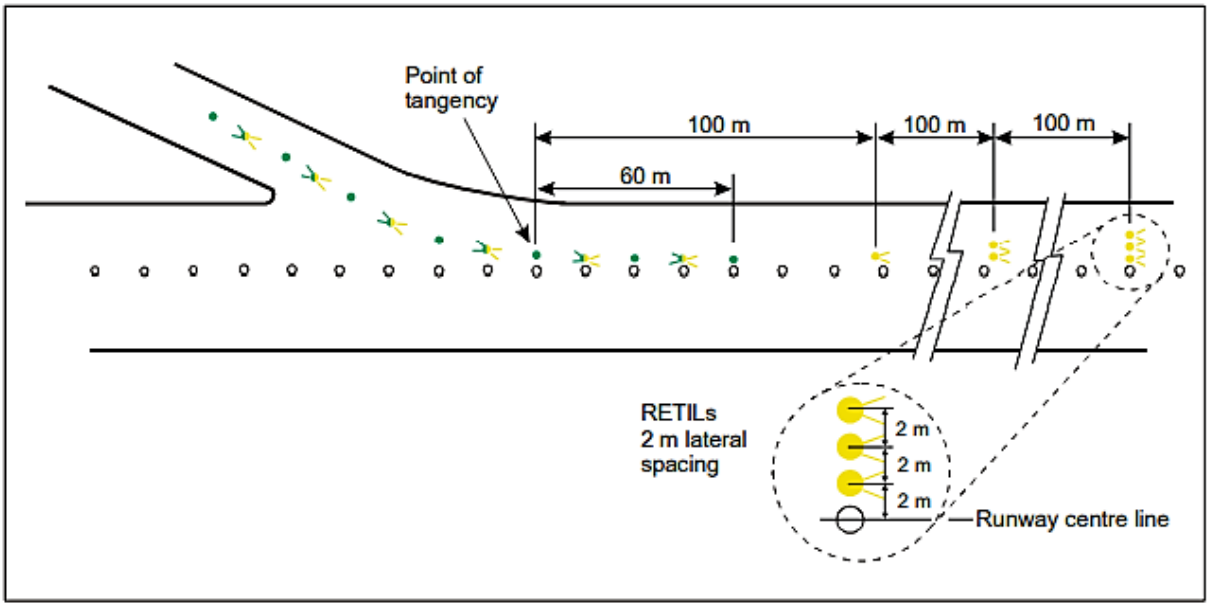
(f) RETILs shall be fixed unidirectional yellow lights aligned to be visible to the pilot of a landing aeroplane approaching the runway.

(g) The indicator lights for the RET shall conform to the specifications in Appendix B, Figure APP.B -6 or Figure 31, as applicable.

(h) RETILs shall be powered separately from another runway lighting to be used when another runway lighting is turned off.

Note: The purpose of RETILs is to provide pilots with information about the distance to the nearest RET on the runway, to improve situational awareness in low visibility conditions, and to enable pilots to apply brakes for more efficient roll-out and runway exit speeds. It is critical for pilots operating at aerodromes with the runway(s) equipped with RETILs to understand their function.

Figure 31: Rapid exit taxiway indicator lights (RETILS)



Source: ICAO Annex 14 Volume 1

191.217 Stopway lights

(a) Stopway lights shall be provided for a stopway intended for use at night.

(b) Stopway lights shall be installed along the entire length of the stopway in two parallel rows parallel to the centre line and parallel to the rows of runway edge lights. Additionally, stopway lights shall be provided across the end of a stopway on a line perpendicular to the stopway axis as close to the end as possible and no more than 3 m outside the end.

(c) Stopway lights shall be permanently installed as unidirectional lights that flash red in the direction of the runway.

191.219 Taxiway centre line lights

(a) Taxiway centre line lights shall be provided on an exit taxiway, taxiway, de-icing/anti-icing facility, and apron intended for use in Runway Visual Range (RVR) conditions less than 350 m to provide continuous guidance between the runway centre line and aircraft stands, except where traffic density is low and taxiway edge lights and centre line marking provide adequate guidance.

(b) Taxiway centre line lights shall be installed on taxiways intended for use at night with a RVR of 350 metres or greater, especially on complex taxiway intersections and exit taxiways, except where traffic density is low and taxiway edge lights and centre line marking provide adequate guidance.

Note: Where it is necessary to delineate the edges of a taxiway, such as on a rapid exit taxiway, a narrow taxiway, or in snowy conditions, taxiway edge lights or markers may be used.

(c) Taxiway centre line lights shall be installed on an exit taxiway, taxiway, de-icing/anti-icing facility, and apron in all visibility conditions when specified as components of an advanced surface movement guidance and control system to provide continuous guidance between the runway centre line and aircraft stands.

(d) Taxiway centre line lights shall be installed on all runways that are part of a standard taxi route and are intended for taxiing in RVR less than 350 metres, except where traffic density is low and taxiway edge lights and centre line marking provide adequate guidance.

Note: For provisions relating to the interlocking of runway and taxiway lighting systems, see OTAR 191.317 (c).

(e) Except as provided in OTAR 191.223 (h), taxiway centre line lights on taxiways other than exit taxiways and on runways that are part of a standard taxi route shall be fixed green lights with beam dimensions sufficient to be visible only from aeroplanes on or near the taxiway.

(f) The lights along the taxiway centre line shall be fixed on an exit taxiway.

(g) Alternate taxiway centre line lights shall alternate between green and yellow from their start near the runway centre line to the perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface, whichever is the furthest from the runway. After that, all lights shall be green (Figure 32). The first light along the exit centre line shall always be green, while the light closest to the perimeter shall always be yellow.

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

Note 2: For characteristics of yellow filters, see Appendix A, 191.APP-A.2.

Note 3: The size of the ILS/MLS critical/sensitive area is determined by the characteristics of ILS/ MLS and other factors. Guidance is provided in Annex 10, Volume I, Attachments C and G.

(h) Where it is necessary to indicate proximity to a runway, taxiway centre line lights shall be fixed lights that alternately display green and yellow from the edge of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface to the runway, whichever is farthest from the runway, and continue to alternately display green and yellow until:

(1) their end point near the runway centre line; or

(2) in the case of the taxiway centre line lights crossing the runway centre line.

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

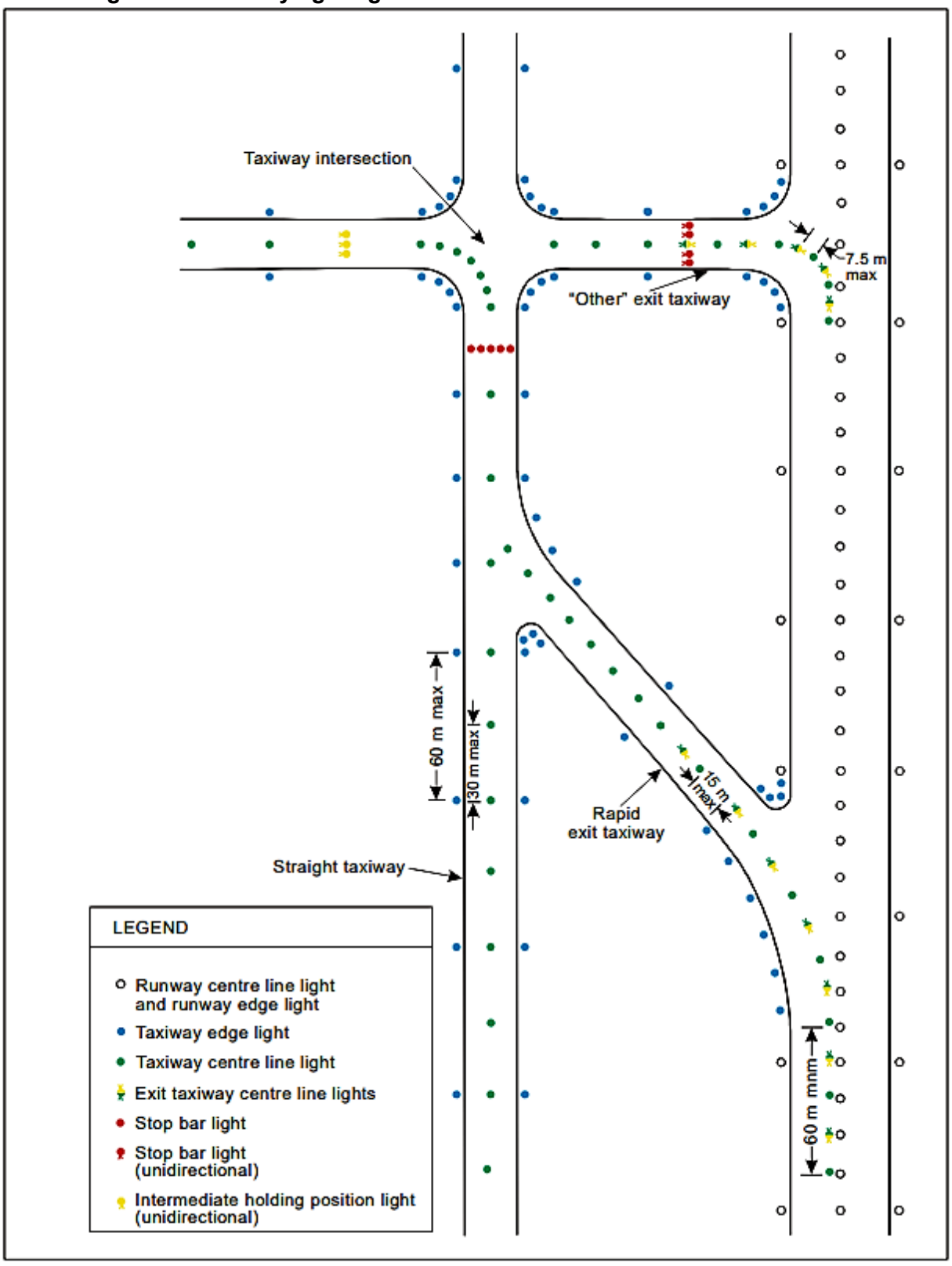
Note 2: The provisions of OTAR 191.223 (h) can be used to help prevent runway incursions.

(i) Taxiway centre line lights shall conform to the specifications in Appendix B, Figure APP.B-12, APP.B-13, or APP.B-14, for taxiways intended for use in visual range conditions less than 350 metres; and Appendix B, Figure APP.B-15 or APP.B-16, for other taxiways.

(j) Where higher intensities are required for operational reasons, taxiway centre line lights on RET intended for use in visual range conditions less than 350 metres shall conform to the specifications in Appendix B, Figure APP.B-12. These lights shall have the same number of brilliancy settings as the runway centre line lights.

(k) Taxiway centre line lights shall normally be located on the taxiway centre line marking unless they unable to be located on the marking and shall be offset by no more than 30 cm.

Figure 28: Taxiway lighting



Source: ICAO Annex 14 Volume 1

(n) Taxiway centre line lights on taxiways shall be spaced at longitudinal intervals of no more than 30 m, except that:

(1) larger intervals not exceeding 60 m may be used where adequate guidance is provided by such spacing due to prevailing meteorological conditions,

(2) intervals less than 30 m shall be provided on short straight sections; and

(3) on a taxiway intended for use in RVR conditions less than 350 m, the longitudinal spacing shall be less than 30 m.

(o) On a taxiway curve, the taxiway centre line lights shall continue at a constant distance from the outside edge of the taxiway curve. The lights shall be a sufficient distance apart to provide a clear indication of the curve.

(p) On a taxiway intended for use in RVR conditions less than 350 m, the lights on a curve shall be spaced no more than 15 metres apart, and on a curve less than 400 metres in radius, the lights shall be spaced no more than 7.5 metres apart. This spacing shall be maintained for 60 metres before and after the curve.

Note 1: The following curve spacings have been determined to be suitable for a taxiway intended for use in RVR conditions of 350 metres or greater:

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

Note 2: See OTAR 191.133 (b) and Figure 2.

(q) On a RET, taxiway centre line lights shall begin at least 60 metres before the start of the taxiway centre line curve and continue beyond the end of the curve to a point on the taxiway centre line where an aeroplane can be expected to reach normal taxiing speed. The lights parallel to the runway centre line shall always be at least 60 cm apart from any row of runway centre line lights, as illustrated in Figure 33.

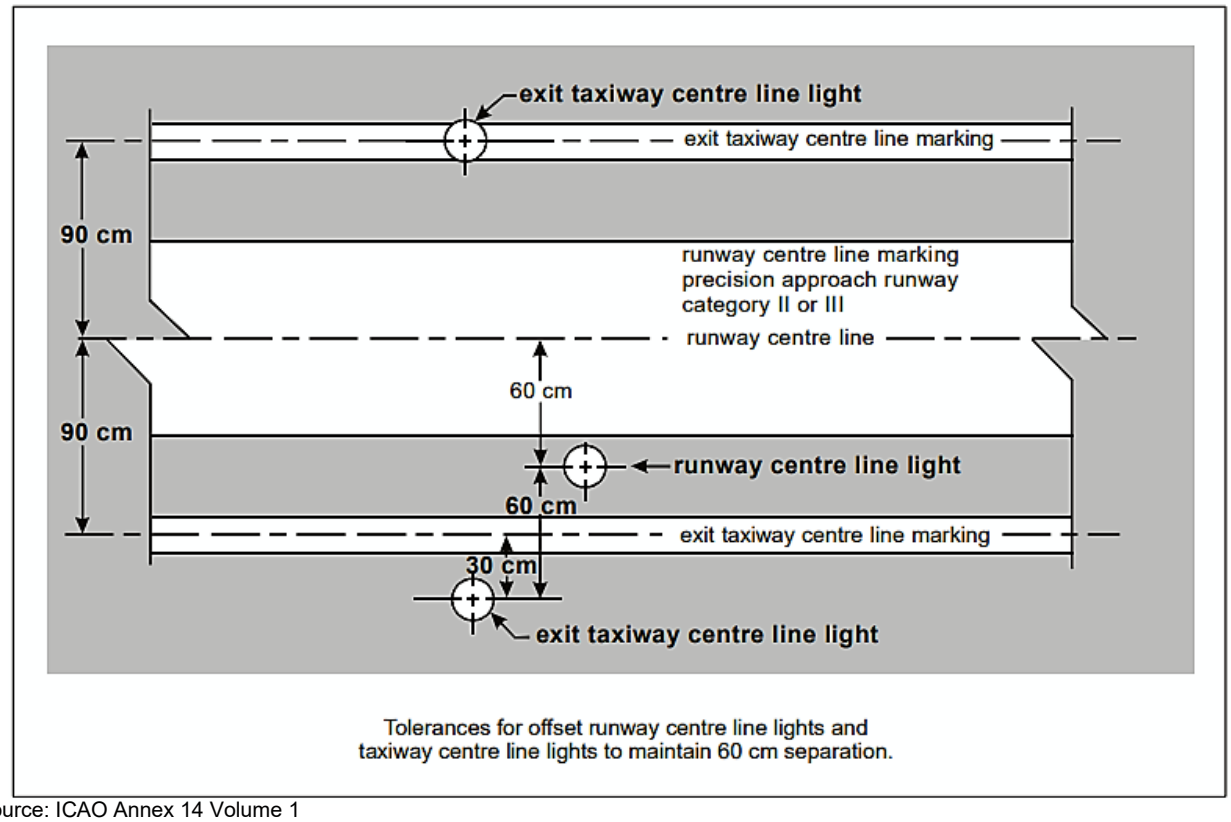
(r) The lights on a RETshall be spaced at not more than 15 m longitudinal intervals, except in the absence of runway centre line lights, where a greater interval of not more than 30 m may be used.

(s) Taxiway centre line lights on non-rapid exit taxiways shall begin where the taxiway centre line marking begins to curve away from the runway centre line and continue at least to the point where the marking leaves the runway. As shown in Figure 33, the first light shall be at least 60 cm from any row of runway centre line lights.

(t) The lights shall be spaced at not more than 7.5 m longitudinal intervals.

(u) On a runway that is part of a standard taxi route and is intended for taxiing in RVR less than 350 m, taxiway centre line lights shall be spaced at longitudinal intervals not exceeding 15 m.

Figure 33: Offset runway and taxiway centre line lights



Source: ICAO Annex 14 Volume 1

191.221 Taxiway edge lights

(a) Taxiway edge lights shall be provided at the edges of a runway turn pad, holding bay, de-icing/anti-icing facility, apron, or other area intended for night use, as well as on a taxiway not equipped with taxiway centre line lights and intended for night use, except where adequate guidance can be achieved through surface illumination or other means, given the nature of the operations.

Note: Taxiway edge markers are described in detail in OTAR 191.271.

(b) Taxiway edge lights shall be installed on any runway that is part of a standard taxi route, is intended for night taxiing, and does not have taxiway centre line lights.

Note: For provisions relating to the interlocking of runway and taxiway lighting systems, see OTAR 191.317 (c).

(c) Taxiway edge lights on straight sections of the taxiway and runways part of a standard taxi route shall be spaced at uniform longitudinal intervals of no more than 60 metres. The lights on a curve shall be spaced less than 60 metres apart to provide a clear indication of the curve.

Note: Guidance on the spacing of taxiway edge lights on curves is provided in OTAC 191-1.

(d) Taxiway edge lights in a holding bay, de-icing/anti-icing facility, or apron, for example, shall be spaced uniformly longitudinally at no more than 60 m intervals.

(e) On a runway turn pad, taxiway edge lights shall be spaced at uniform longitudinal intervals of no more than 30 metres.

(f) The lights shall be located as close to the edges of the taxiway, runway turn pad, holding bay, de-icing/anti-icing facility, apron, or runway as possible, or not more than 3 m away from the edges.

(g) Taxiway edge lights shall be permanently illuminated in blue. The lights shall be visible up to 75 degrees above the horizontal and at all azimuth angles necessary to guide a pilot taxiing in either direction. At an intersection, exit, or curve, the lights shall be shielded to the maximum extent possible to prevent them from being seen at azimuth angles where they could be confused with other lights.

(h) Taxiway edge lights shall have an intensity of at least 2 cd between 0° and 6° vertical and 0.2 cd between 6° and 75° vertical.

191.223 Runway turn pad lights

(a) Runway turn pad lights shall provide continuous guidance on a runway turn pad intended for use when the RVR is less than 350 metres, allowing an aeroplane to complete a 180-degree turn and align with the runway centre line.

(b) Runway turn pad lights shall be provided on a runway turn pad intended for use at night.

(c) Runway turn pad lights shall normally be located on the runway turn pad marking, except in cases where it is impractical to locate them on the marking, where they may be offset by no more than 30 cm.

(d) Runway turn pad lights shall be spaced no more than 15 metres apart longitudinally along a straight section of the runway turn pad marking.

(e) The spacing between runway turn pad lights on a curved section of the runway turn pad marking shall not exceed 7.5 metres.

(f) Runway turn pad lights shall be unidirectional fixed green lights with beam dimensions sufficient to be visible only from aircraft on or approaching the runway turn pad.

(g) The runway turn pad lighting shall conform to the specifications outlined in Appendix B, Figure APP.B-13, APP.B-14, or APP.B-15, as applicable.

191.225 Stop bars

(a) A stop bar shall be installed at each runway-holding position serving a runway when the runway is intended to be used in RVR of less than 550 metres, except where:

(1) appropriate aids and procedures are available to assist in preventing accidental incursions of traffic onto the runway; or

(2) operational procedures exist to limit, in RVR less than 550 metres, the number of:

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

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

(b) Where a taxiway/runway intersection has more than one stop bar, only one stop bar shall be illuminated at any time.

(c) A stop bar shall be provided at an intermediate holding position when it is desired to supplement markings with lights and provide visual traffic control.

(d) Stop bars shall be placed across the taxiway at the point where traffic shall come to a halt. Where the additional lights specified in OTAR 191.229 (f) are used, they shall be located at least 3 metres from the taxiway edge.

(e) Stop bars shall be composed of lights spaced uniformly across the taxiway at intervals of no more than 3 m, displaying red in the intended direction(s) of approach to the intersection or runway-holding position.

Note: Where additional lighting is required to increase the visibility of an existing stop bar, it is installed uniformly.

(f) A pair of elevated lights shall be added to each end of the stop bar where the in-pavement stop bar lights may be obscured from view by snow or rain or where the pilot may be required to stop the aircraft in a position so close to the lights that they are obscured from view by the structure of the aircraft.

(g) Stop bars installed at a runway-holding position shall be unidirectional and illuminated red in the direction of the approach of the runway.

(h) Where the additional lights specified in OTAR 191.229 (f) are used, they shall have the same characteristics as the stop bar lights but shall be visible to approaching aircraft up to the stop bar position.

(i) Stop bar lights shall have an intensity in red light, and a beam spread consistent with the specifications in Appendix B, Figure APP.B-12 through APP.B-16, as applicable.

(j) Where a wide beam fixture is required, the red-light intensity and beam spreads of stop bar lights shall conform to Appendix B, Figure APP.B-17 or APP.B-19.

(k) The lighting circuit shall be designed in such a way that:

(1) stop bars located across entrance taxiways are selectively switchable,

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

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

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

Note 1: Electrical systems must be designed to ensure that all of the lights on a stop bar do not fail simultaneously. Guidance on this issue is given in the Aerodrome Design Manual (Doc 9157), Part 5.

Note 2: A stop bar is designed to be manually or automatically controlled by air traffic services.

Note 3: Runway incursions can occur in all weather and visibility conditions. The installation of stop bars at runway holding positions and their use at night and in conditions with visibility greater than the RVR of 550 metres can all contribute to the effectiveness of runway incursion prevention measures.

191.227 Intermediate holding position lights

(a) Unless a stop bar is installed, intermediate holding position lights shall be provided at an intermediate holding position intended for use when the RVR is less than 350 metres.

(b) Intermediate holding position lights shall be provided at intermediate holding positions where stop-and-go signals, such as those provided by a stop bar are unnecessary.

(c) Intermediate holding position lights shall consist of three fixed unidirectional lights that illuminate yellow in the direction of approach to the intermediate holding position and have a light distribution similar to that of taxiway centre line lights if provided. The lights shall be symmetrically spaced around and perpendicular to the taxiway centre line, with individual lights 1.5 m apart.

Note: Refer to OTAR 191.165 for information on the marking of intermediate holding positions.

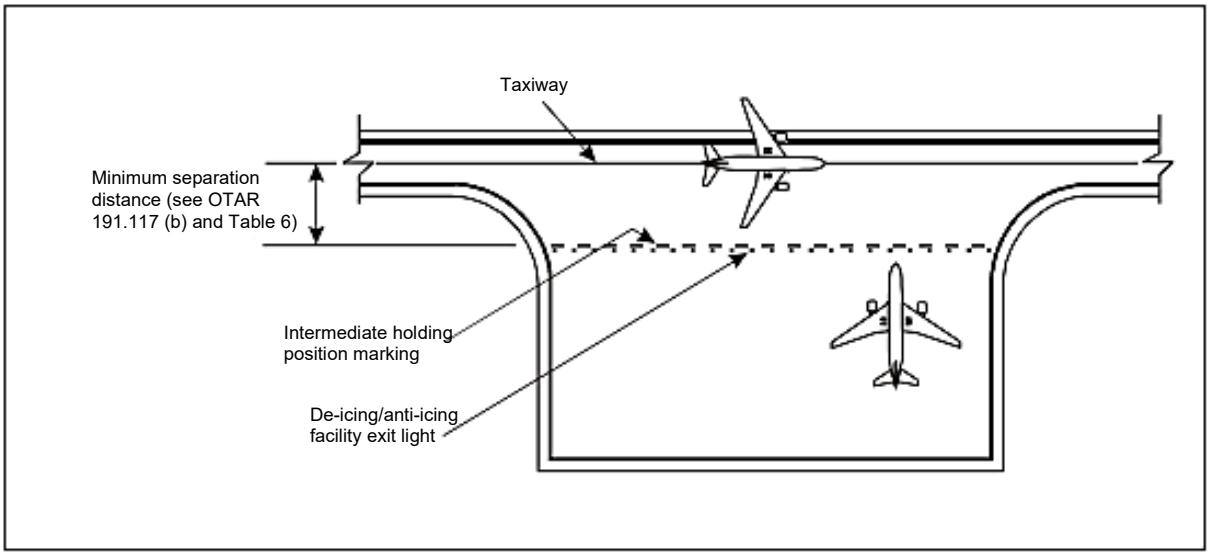
191.229 De-icing/anti-icing facility exit lights

(a) De-icing/anti-icing facility exit lights shall be provided at exit boundary of the the remote de-icing/anti-icing facility adjacent to a taxiway.

(b) Exit lights for remote de-icing/anti-icing facilities shall be located 0.3 m inward of the intermediate holding position marking displayed at the f exit boundary of the facility.

(c) Exit lights for de-icing/anti-icing facilities shall consist of in-pavement fixed unidirectional lights with a light distribution similar to taxiway centre line lights, spaced at intervals of 6 m and showing yellow in the direction of approach to the exit boundary (see Figure 34).

Figure 34: Typical remote de-icing/anti-icing facility



Source: ICAO Annex 14 Volume 1

191.231 Runway guard lights

(a) Runway guard lights, Configuration A, shall be provided at each taxiway/runway intersection associated with a runway intended for use in the following conditions:

(1) RVR less than 550 metres without a stop bar; and

(2) RVR between 550 and 1200 metres and high traffic density.

Note 1: Runway incursions can occur in all weather and visibility conditions. The use of runway guard lights at runway-holding positions can be an effective means of preventing runway incursions. When pilots and drivers of vehicles are operating on taxiways, runway guard lights alert them that they are about to enter a runway.

Note 2: When deemed necessary, runway guard lights in Configuration B may be used in addition to runway guard lights in Configuration A. Guidance on the design, operation and location of runway guard lights in Configuration B is given in the OTAC 191-1.

(b) As part of the runway incursion prevention measures, runway guard lights in either Configuration A or B shall be installed at each taxiway/runway intersection with identified runway incursion hot spots and used in all weather conditions, day and night.

(c) The runway guard lights in Configuration B shall not be used in conjunction with a stop bar.

(d) At a runway/taxiway intersection with more than one runway-holding position, only the set of runway guard lights associated with the operational runway-holding position shall be illuminated.

(e) Each side of the taxiway on the holding side of the runway-holding position marking shall have runway guard lights in Configuration A.

(f) Runway guard lights, Configuration B, shall be located across the taxiway from the runway holding position marking on the holding side.

(g) The configuration A runway guard lights shall consist of two pairs of yellow lights.

(h) Where it is necessary to increase the contrast between the on and off states of Configuration A runway guard lights,which are intended for use during the day, a visor large enough to prevent sunlight from entering the lens without impairing the function of the fixture shall be installed above each lamp.

Note: Another device or design, such as specially designed optics, may be used as an alternative to a visor

(i) Runway guard lights, Configuration B, shall consist of yellow lights evenly spaced across the taxiway at a distance of 3 metres.

(j) The light beam shall be unidirectional and illuminate in the direction of approach to the runway holding position in yellow.

Note: For guidance on orientation and aiming of runway guard lights, see the Aerodrome Design Manual (Doc 9157), Part 4

(k) The yellow light intensity and beam spreads of lights in Configuration A shall meet the specifications in Appendix B, Figure APP.B-24.

(l) When runway guard lights are intended for use during the day, their yellow light intensity and beam spreads shall conform to the specifications in Appendix B, Figure APP.B-25.

(m) When runway guard lights are specified as components of an advanced surface movement guidance and control system, the yellow light intensity and beam spreads of lights of Configuration A shall conform to the specifications in Appendix B, Figure APP.B-25.

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

(n) The yellow light intensity and beam spread of the lights in Configuration B shall conform to the specifications in Appendix B, Figure APP.B-12.

(o) Where runway guard lights are to be used during the day, the yellow light intensity and beam spreads of lights of Configuration B shall meet the specifications in Appendix B, Figure APP.B-20.

(p) Where runway guard lights are specified as components of an advanced surface movement guidance and control system, the yellow light intensity and beam spreads of lights of Configuration B shall conform to the specifications in Appendix B, Figure APP.B-20.

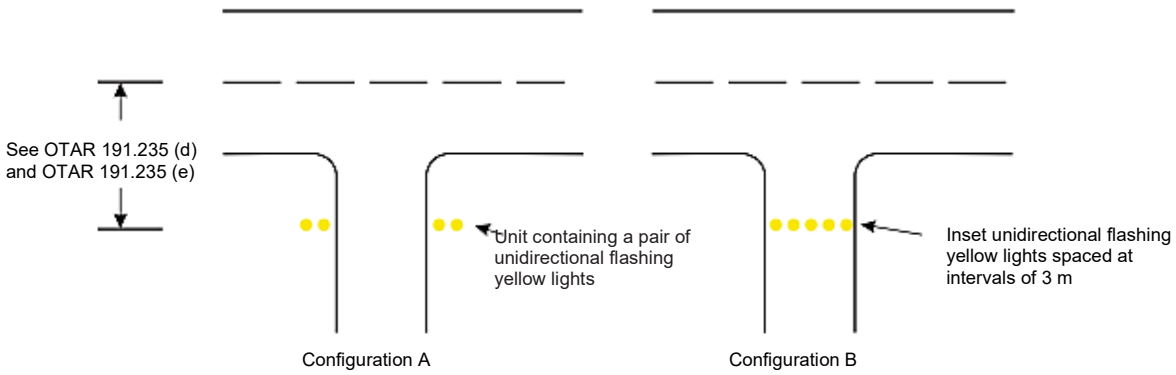
(q) The lights in each unit of Configuration A shall be illuminated alternately.

(r) For Configuration B, adjacent lights shall be illuminated alternately, while alternative lights shall be illuminated simultaneously.

(s) The lights shall be illuminated between 30 and 60 cycles per minute, with equal and opposite periods of light suppression and illumination in each light.

Note: The rise and fall times of the lamp determine the optimal flash rate. Runway guard lights, Configuration A, have been found to look best when operated at 45 to 50 flashes per minute per lamp when installed on 6.6 amp series circuits. Runway guard lights, Configuration B, have been found to look best when operated at 30 to 32 flashes per minute per lamp when installed on 6.6 amp series circuits.

Figure 35: Runway guard lights



Source: CAP168

191.233 Apron floodlighting

(a) Apron floodlighting shall be provided on an apron, a de-icing/anti-icing facility, and a designated isolated aircraft parking position for use at night.

Note 1: Where a de-icing/anti-icing facility is close to the runway and permanent floodlighting would confuse pilots, alternate means of illumination may be required.

Note 2: The designation of an isolated aircraft parking position is specified in Subpart F. See also OTAR 191.223 (a) and OTAR 191.225 (a)

Note 3: For guidance on orientation and aiming of runway guard lights, see the Aerodrome Design Manual (Doc 9157), Part 4

(b) Apron floodlights shall be placed to provide adequate illumination for all apron service areas while minimising glare for aircraft pilots in flight and on the ground, aerodrome and apron controllers, and apron personnel. Floodlights shall be arranged and aimed so that an aircraft stand receives light from two or more directions to minimise shadows.

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

(d) At a minimum, the average illuminance shall be as follows:

(1) Aircraft stand:

(i) — horizontal illuminance — 20 lux with a uniformity ratio (average to a minimum) of not more than 4 to 1; and

(ii) — vertical illuminance — 20 lux at the height of 2 m above the apron in relevant directions.

(2) Other apron areas:

(i) — horizontal illuminance equal to 50 per cent of the average illuminance on the aircraft stands with a uniformity ratio of not more than 4 to 1 (average to a minimum).

191.235 Aircraft stand manoeuvring guidance lights

(a) Unless adequate guidance is provided by other means, aircraft stand manoeuvring guidance lights shall be provided to facilitate the positioning of an aircraft on an aircraft stand on a paved apron or a de-icing/anti-icing facility intended for use in low visibility conditions.

(b) Aircraft stand manoeuvring guidance lights shall be placed in the same location as the aircraft stand markings.

(c) Other than those indicating a stop position, aircraft stand manoeuvring guidance lights shall be fixed yellow lights visible throughout the segments for which they are intended to provide guidance.

(d) The lights denoting lead-in, turning, and lead-out lines shall be spaced no more than 7.5 metres apart on curves and 15 metres on straight sections.

(e) The stop lights shall be fixed unidirectional red lights.

(f) The intensity of the lights shall be sufficient for the visibility and ambient light conditions under which the aircraft stand is intended to be used.

(g) The lighting circuit shall be designed so that the lights can be turned on to indicate that an aircraft stand is to be used and off to indicate that it is not.

191.237 Road-holding position light

(a) A road-holding position light shall be provided at each road-holding position serving a runway when it is intended that the runway be used in RVR less than 350 m.

(b) When the runway is intended to be used in RVR ranging from 350 m to 550 m, a road-holding position light shall be installed at each road-holding position serving a runway.

(c) A road-holding position light shall be installed adjacent to the holding position marking 1.5 m (0.5 m) from one edge of the road, i.e. left or right, depending on local traffic regulations.

Note: The mass and height limitations and the frangibility requirements of navigation aids located on runway strips are detailed in Section 9.9.

(d) The road-holding position light shall include either a controllable red (stop)/green (go) traffic light or a flashing red light.

Note: The controllable red (stop)/green (go) traffic lights are intended to be controlled by air traffic services.

(e) The road-holding position light beam shall be unidirectional and aligned so that the driver of a vehicle approaching the holding position can see it.

(f) The intensity of the light beam shall be adequate for the visibility and ambient light conditions under which the holding position is intended to be used but shall not dazzle the driver.

Note: The OTAR 191.241 (e) and (f) requirements are likely to be met by commonly used traffic lights.

(g) The flashing-red light shall have a frequency of 30 to 60 flashes per minute.

191.239 No-entry bar

(a) A no-entry bar shall be installed across a taxiway intended to be used as an exit-only taxiway to help prevent accidental traffic access to that taxiway.

Note: Runway incursions can occur in any visibility or weather conditions. No-entry bars can be used as part of effective runway incursion prevention measures.

(b) A no-entry bar shall be installed across the taxiway at the end of an exit-only taxiway to prevent traffic from entering the taxiway in the wrong direction.

(c) A no-entry bar shall accompany a no-entry sign and/or marking.

(d) A no-entry bar shall be made up of unidirectional lights that show red in the intended direction(s) of approach to the runway and are spaced at uniform intervals of no more than 3 m.

Note: Where necessary to increase visibility extra lights are installed uniformly.

(e) A pair of elevated lights shall be added to each end of the no-entry bar where the in-pavement no-entry bar lights may be obscured from a pilot 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 the structure of the aircraft blocks their view.

(f) The red light intensity and beam spreads of no-entry bar lights shall meet the specifications in Appendix B, Figure s APP.B-12 through APP.B-16, as applicable.

(g) When no-entry bars are specified as components of an advanced surface movement guidance and control system, and higher intensities are required from an operational standpoint to maintain ground movements at a certain speed in very low visibilities or bright daytime conditions, the intensity in red light and beam spreads of no-entry bar lights shall be in accordance with the specifications of Appendix B, Figure APP.B-17, APP.B-18, or APP.B-19.

Note: High-intensity no-entry bars are typically used only when absolutely necessary and after a specific study.

(h) When a wide beam fixture is required, the intensity in red light and beam spreads of no-entry bar lights shall be in accordance with Appendix B, Figure APP.B-17 or APP.B-19 specifications.

(i) Taxiway centre line lights installed beyond the no-entry bar and facing the runway shall not be visible from the taxiway.

Subpart L – Signs

191.245 General information

(a) To meet the requirements of OTAR 191.327, signs shall be provided to convey mandatory instruction, information on a specific location or destination in a movement area, or to provide other information.

Note: Specifications for information marking can be found in OTAR 191.177.

(b) A variable message sign shall be provided when:

(1) the instruction or information displayed on the sign is only relevant for a limited time; and/or

(2) variable predetermined information is required to meet the requirements of OTAR 191.327.

(c) Signs shall be frangible. Those located near a runway or taxiway shall be sufficiently low to allow clearance for propellers and jet engine pods. The installed height of the sign shall not exceed the dimension shown in the appropriate column of Table 15.

Table 15: Location distances for taxiing guidance signs, including runway exit signs

Sign height (mm)				Perpendicular distance from the defined taxiway pavement edge to near the side of the sign	Perpendicular distance from the defined runway pavement edge to the near side of the sign
Code number	Legend	Face (min.)	Installed (max.)		
1 or 2	200	300	700	5–11 m	3–10 m
1 or 2	300	450	900	5–11 m	3–10 m
3 or 4	300	450	900	11–21 m	8–15 m
3 or 4	400	600	1 100	11–21 m	8–15 m

(d) Signs shall be rectangular, as illustrated in Figures 36 and 38, with the longer side horizontal.

(e) The only red signs in the movement area shall be mandatory instruction signs.

(f) The inscriptions on a sign shall comply with the provisions of Appendix D.

(g) Signs shall be illuminated in accordance with Appendix D when they are intended to be used:

(1) in RVR less than 800 m; or

(2) at night in conjunction with instrument runways; or

(3) at night in conjunction with non-instrument runways where the code number is 3 or 4.

(h) When used at night in conjunction with non-instrument runways with code numbers 1 or 2, signs shall be retroreflective and/or illuminated in accordance with the provisions of Appendix D.

(i) When not in use a variable message sign shall have a blank face.

(j) In the event of a failure, a variable message sign shall not provide information that could lead to an unsafe action by a pilot or vehicle driver.

(k) The time interval between messages on a variable message sign shall be as short as possible and shall not exceed 5 seconds.

191.247 Mandatory instruction signs

(a) A mandatory instruction sign shall be provided to identify a location beyond which an aircraft taxiing or vehicle shall not proceed unless authorised by the aerodrome control tower.

(b) Mandatory instruction signs shall include runway designation signs, category I, II or III holding position signs, runway-holding position signs, road-holding position signs and NO ENTRY signs.

Note: Specifications for road-holding position signs can be found in OTAR 191.259.

(c) A runway designation sign shall be used with a pattern "A" runway-holding position marking at a taxiway/runway intersection or a runway/runway intersection.

(d) A runway-holding position marking in pattern "B" shall be accompanied by a holding position sign in category I, II, or III.

(e) A runway-holding position sign shall be added to a pattern "A" runway-holding position marking at a runway-holding position established in accordance with OTAR 191.173.

Note: Specifications for runway-holding position marking can be found in OTAR 191.163 (c).

(f) At a taxiway/runway intersection, a runway designation sign shall be supplemented with a location sign in the outboard (furthest from the taxiway) position, as appropriate.

Note: For more information on the characteristics of location signs, see OTAR 191.253.

(g) When entering into a restricted area is prohibited, a NO ENTRY sign shall be displayed.

(h) A runway designation sign shall be located on each side of the runway-holding position marking facing the direction of approach to the runway at a taxiway/runway intersection or a runway/runway intersection.

(i) A category I, II, or III holding position sign shall be located on each side of the runway-holding position marking facing the direction of the approach to the critical area.

(j) A NO ENTRY sign shall be placed at the beginning of the area where entry is prohibited, on each side of the taxiway, as viewed by the pilot.

(k) A runway-holding position sign shall be placed on each side of the runway-holding position established in accordance with 191.161 (c), facing the approach to the obstacle limitation surface or ILS/MLS critical/sensitive area, as applicable.

(l) A mandatory instruction sign shall be composed of a white inscription on a red background.

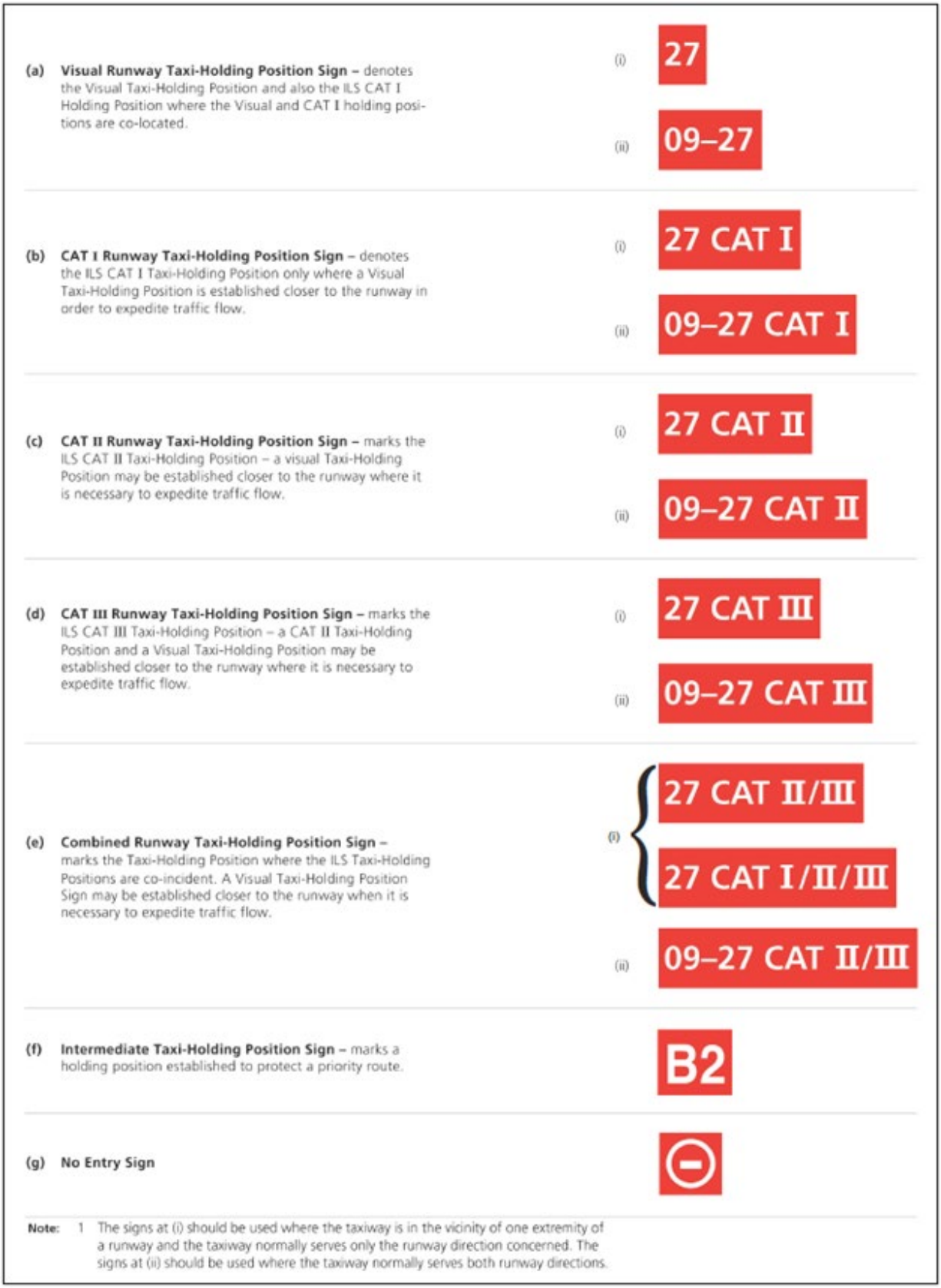
(m) Where the conspicuity of the inscription on a mandatory instruction sign needs to be increased due to environmental or other factors, the outside edge of the white inscription shall be supplemented by a black outline measuring 10 mm in width for runway codes 1 and 2, and 20 mm in width for runway codes 3 and 4.

(n) The inscription on a runway designation sign shall consist of the runway designations of the intersecting runway adequately oriented with respect to the viewing position of the sign, except that a runway designation sign installed in the vicinity of a runway extremity may display only the runway designation of the concerned runway extremity .

(o) The inscription on a category I, II, III, joint II/III or joint I/II/III holding position sign shall consist of the runway designator followed by CAT I, CAT II, CAT III, CAT II/III or CAT I/II/III, as applicable.

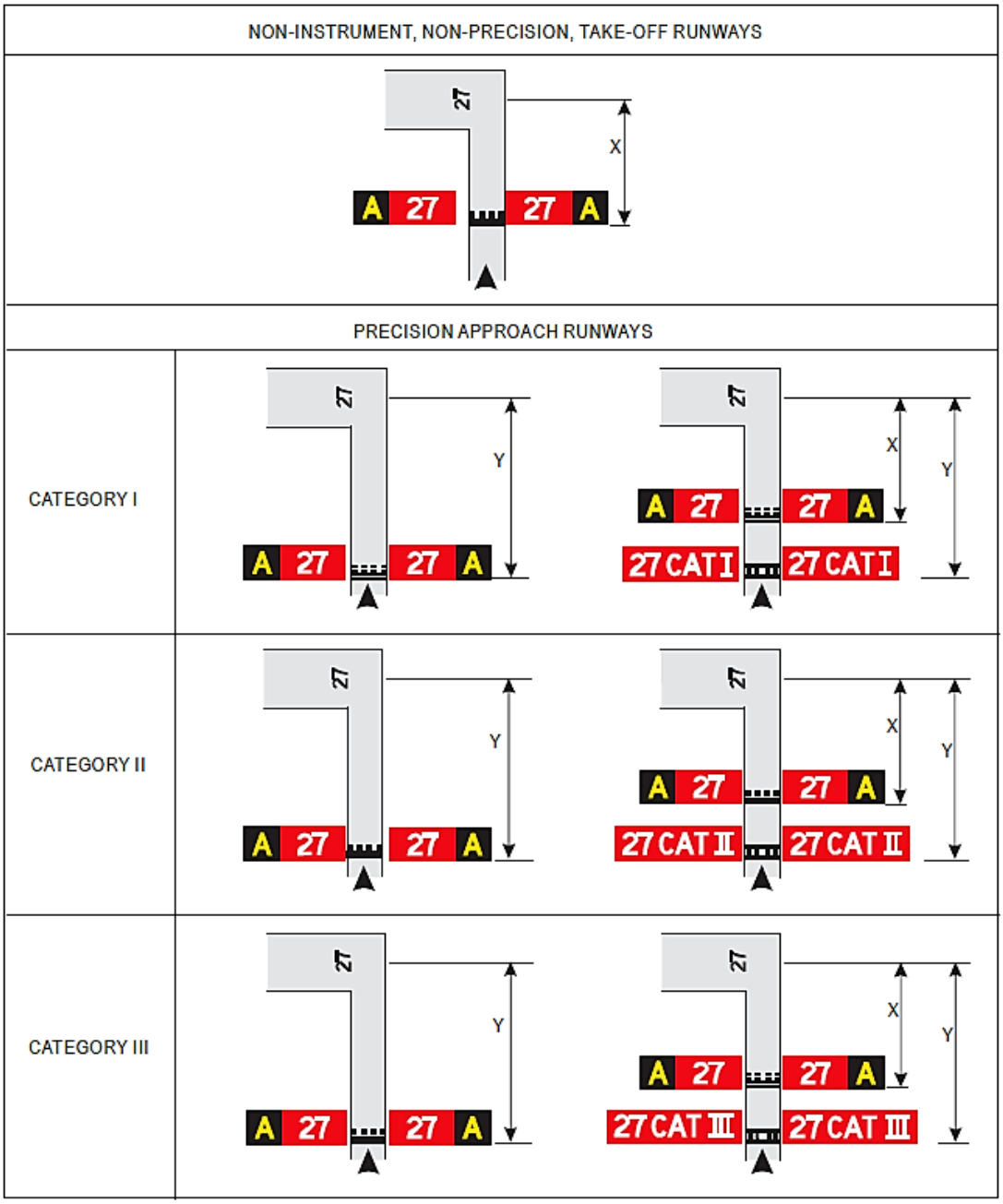
(p) The inscription on a NO ENTRY sign shall conform to the format shown in Figure 36.

Figure 32: Mandatory instruction signs



Source: CAP168

Figure 37: Examples of sign positions at taxiway/runway intersections



Source: ICAO Annex 14 Volume 1

Note: The distance X is determined using the formula in Table 7. Distance Y is established at the edge of the ILS/MLS critical/sensitive area.

191.249 Information signs

(a) An information sign shall be provided where a sign is required to identify a specific location or routing (direction or destination) information.

(b) Information signs shall include direction signs, location signs, destination signs, runway exit signs, runway vacated signs and intersection take-off signs.

(c) A runway exit sign shall be provided where there is an operational need to identify a runway exit.

(d) A runway vacated sign shall be provided where the exit taxiway lacks taxiway centre line lighting, and it is necessary to indicate to a pilot departing a runway the perimeter of the ILS/MLS critical/sensitive area or the lower edge of the inner transitional surface, whichever is farther from the runway centre line.

Note: OTAR 191.223 specifies the colour coding of taxiway centre line lights.

(e) When an operational requirement exists, an intersection take-off sign shall be provided to indicate the remaining take-off run available (TORA) for intersection take-offs.

(f) A destination sign shall be provided where necessary to indicate the direction to a specific location on the aerodrome, such as the cargo area or general aviation.

(g) A combined location and direction sign shall be provided when it is intended to indicate routing information prior to a taxiway intersection.

(h) A direction sign shall be provided when it is necessary for operational purposes to identify the designation and direction of taxiways at an intersection.

(i) A location sign shall be provided at an intermediate holding position.

(j) Except at a runway/runway intersection, a location sign shall be provided in conjunction with a runway designation sign.

(k) A location sign shall be installed in conjunction with a direction sign unless an aeronautical study indicates it is unnecessary.

(l) A location sign shall be provided where necessary to indicate taxiways exiting an apron or taxiways beyond an intersection.

(m) A barricade, direction sign, and/or other appropriate visual aid shall be used where a taxiway terminates at an intersection, such as a "T," and identification is required.

(n) A sign indicating that the runway has been vacated shall be located on at least one side of the taxiway. The distance between the sign and the runway centre line shall not be less than the greater of the following:

(1) the distance between the runway centre line and the perimeter of the ILS/MLS critical/sensitive area; or

(2) the distance between the runway centre line and the lower edge of the inner transitional surface.

(o) Where a taxiway location sign is provided in conjunction with a runway vacated sign, it shall be placed outboard of the runway vacated sign.

(p) An intersection take-off sign shall be located at the left-hand side of the entry taxiway. The distance between the sign and the runway centre line shall be at least 60 metres in cases where the code number is 3 or 4, and at least 45 metres where the code number is 1 or 2.

(q) When used with a runway designation sign, the taxiway location sign shall be positioned outboard of the runway designation sign. Normally, a destination sign shall not be located alongside a location or direction sign.

(r) A non-location information sign shall not be placed adjacent to a mandatory instruction sign.

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

(t) Besides a location sign, an information sign shall consist of a black inscription on a yellow background. A location sign shall have a yellow inscription on a black background and a yellow border if it is a stand-alone sign.

(u) On a runway exit sign, the inscription shall include the designation of the exit taxiway and an arrow indicating the direction to follow.

(v) The inscription on a runway vacated sign shall depict the pattern A runway-holding position marking as shown in Figure 38.

(w) On an intersection take-off sign, the inscription shall consist of a numerical message indicating the remaining take-off run available in metres, as well as an arrow appropriately located and oriented, indicating the direction of the take-off, as shown in Figure 38.

(x) The inscription on a destination sign shall include an alpha, alphanumerical, or numerical message identifying the destination and an arrow indicating the direction in which to proceed, as illustrated in Figure 38.

(y) On a direction sign, the inscription shall consist of an alpha or alphanumerical message identifying the taxiway(s) and an arrow or arrows oriented appropriately, as shown in Figure 38.

(z) The inscription on a location sign shall consist solely of the designation of the taxiway, runway, or other pavement on which the aircraft is currently operating or is about to operate and shall not include any arrows.

(aa) Where a series of intermediate holding positions on the same taxiway shall be identified, the location sign shall include both the taxiway designation and a number.

(bb) When a location sign and direction signs are combined, the following rules apply:

(1) all direction signs relating to left turns shall be placed on the left side of the location sign, and all direction signs relating to right turns shall be placed on the right side of the location sign, except where the junction consists of a single intersecting taxiway,

(2) the direction signs shall be positioned so that the arrows' direction deviates increasingly from vertical as the corresponding taxiway's deviation increases of the taxiway,

(3) where the direction of the location taxiway changes significantly beyond the intersection, an appropriate direction sign shall be placed adjacent to the location sign; and

(4) adjacent direction signs shall be denoted by a vertical black line, as shown in Figure 38.

(cc) A taxiway shall be identified by a single letter, two letters, or a combination of a letter or letters followed by a number that is used only once on an aerodrome.

(dd) When designating taxiways, words such as “inner” and “outer” shall be avoided wherever possible.

(ee) To avoid confusion with the numerals 1 and 0 and the closed marking, the letters I, O, and X shall not be used to designate taxiways.

(ff) In the manoeuvring area, numbers shall only be used to identify runways.

(gg) Apron stand designators shall not be used interchangeably with taxiway descriptors.

Figure 38: Information signs

Note: Common abbreviations used for destination signs are:
APRON - general parking, servicing and loading areas
GEN AV - general aviation
STANDS - aircraft stands
FUEL -areas where aircraft are fuelled or serviced
TERM - gate positions at which aircraft are loaded or unloaded
CIVIL - areas set aside for civil aircraft
MIL - areas set aside for military aircraft
PAX - areas set aside for passenger handling
CARGO - areas set aside for cargo handling
INTL - areas set aside for handling international flights
HELI - helicopter parking

Figure 39: Examples of taxi guidance signs at taxiway intersections

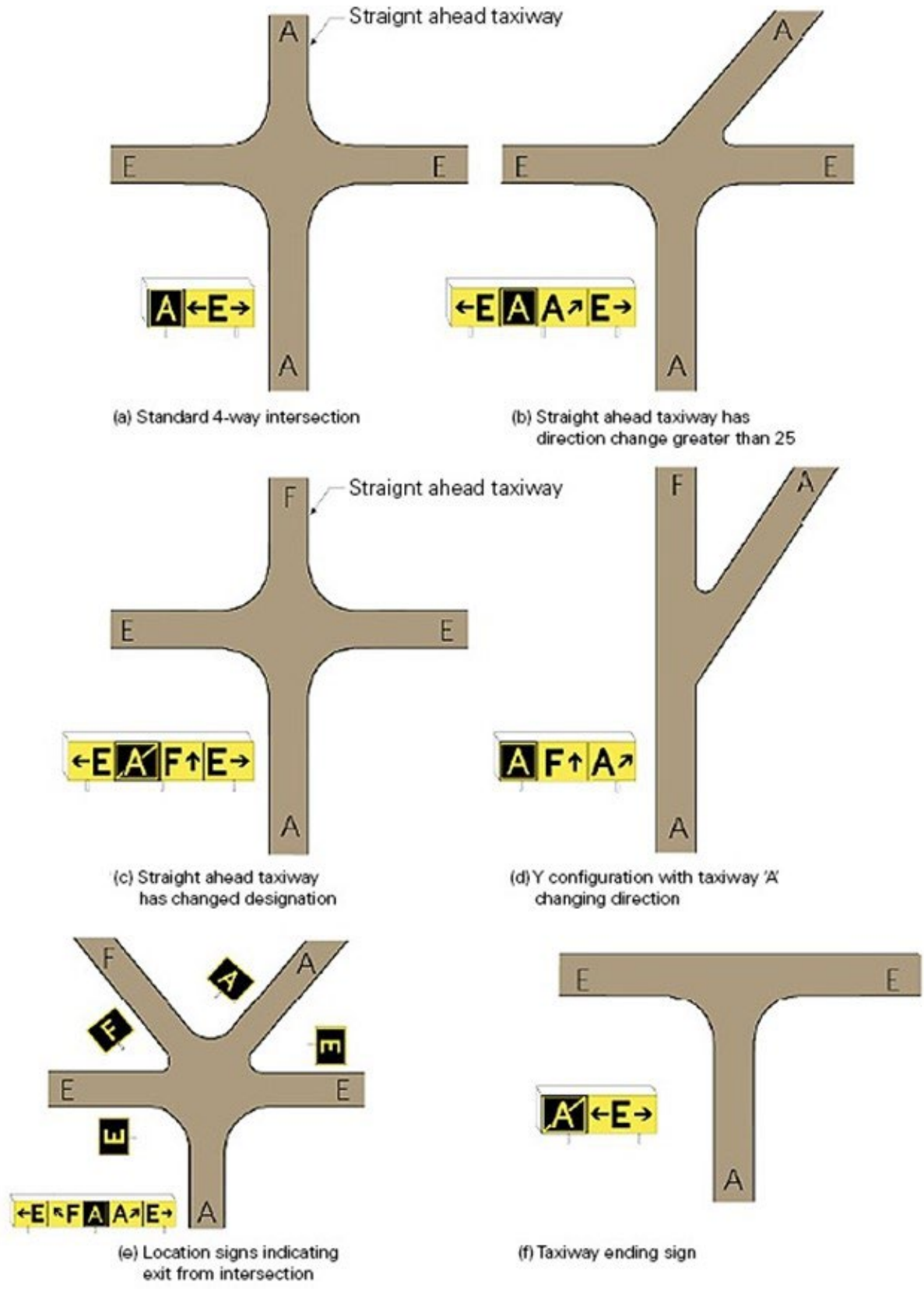
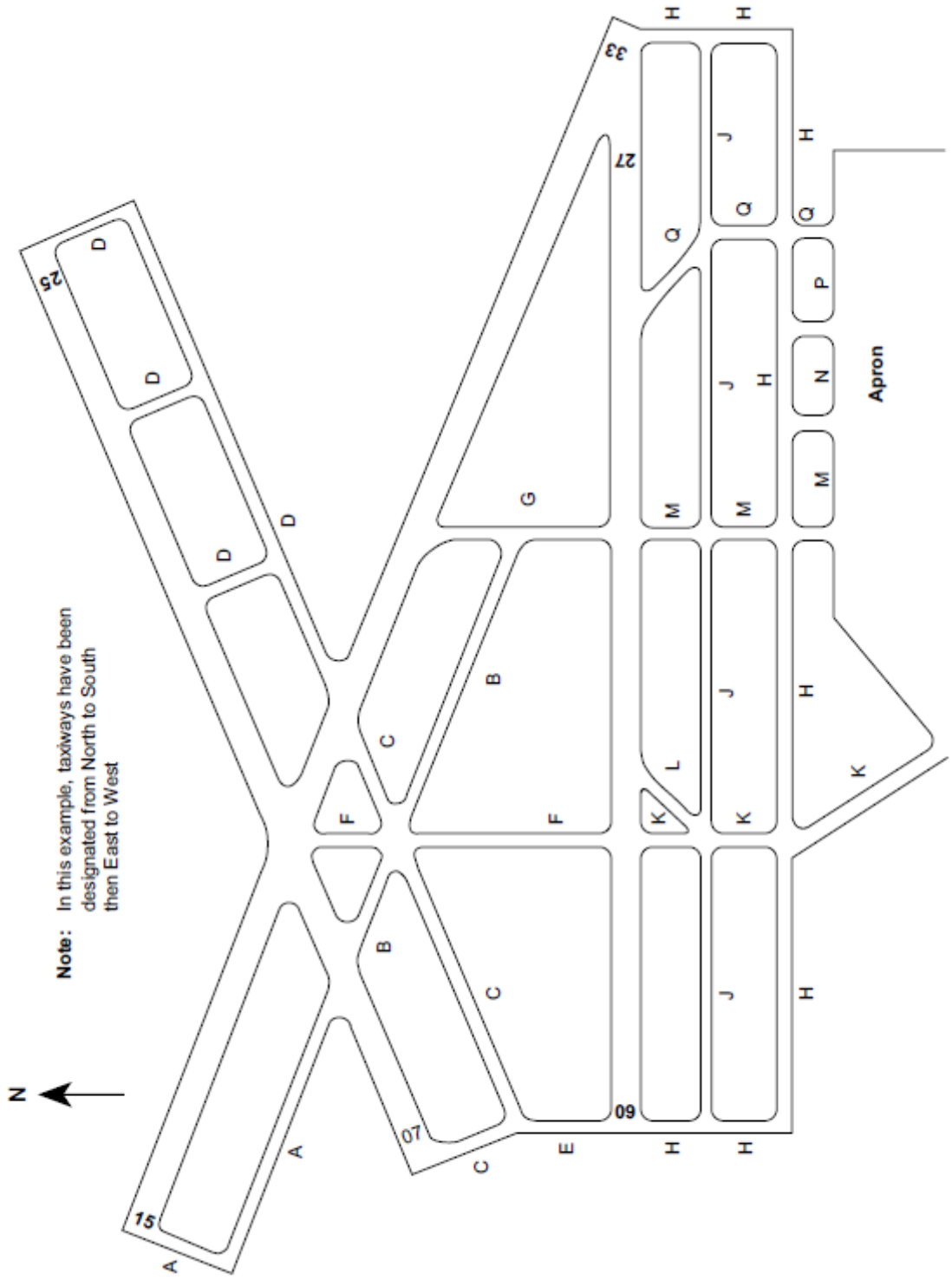


Figure 40: Example of designating taxiway



Source: CAP168

191.251 VOR aerodrome checkpoint sign

(a) When a VOR aerodrome checkpoint is established, it shall be marked and signed as a VOR aerodrome checkpoint.

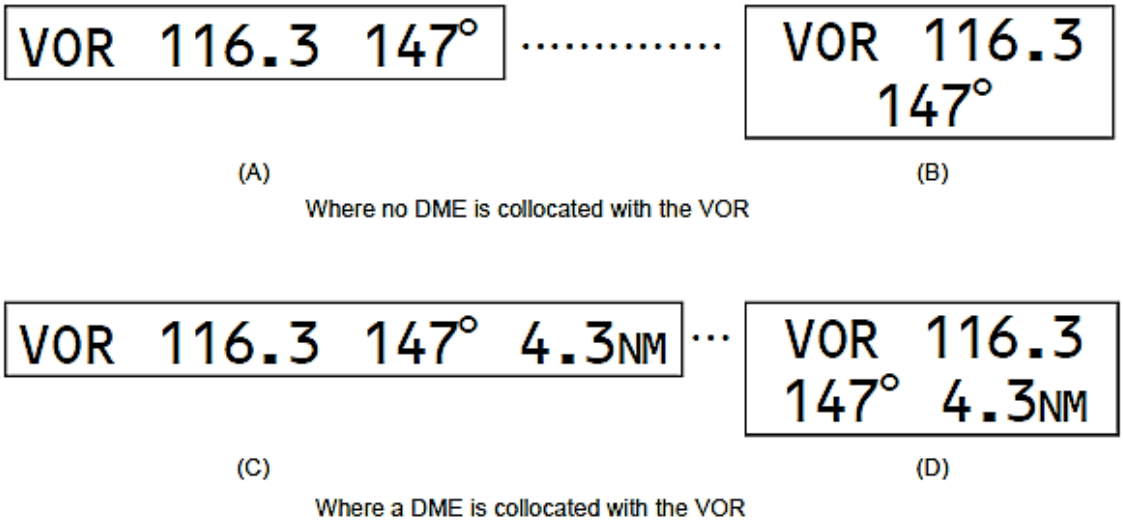
Note: Refer to OTAR 191.167 for information on marking VOR aerodrome checkpoints.

(b) A VOR aerodrome checkpoint sign shall be located as close to the checkpoint as possible so that the inscriptions are visible from the cockpit of an aircraft adequately aligned with the VOR aerodrome checkpoint marking.

(c) A VOR aerodrome checkpoint sign shall consist of an inscription in black on a yellow background

(d) Inscriptions on a VOR checkpoint sign shall follow one of the alternatives depicted in Figure 41.

Figure 41: VOR aerodrome checkpoint sign



VOR - an abbreviation identifying this as a VOR checkpoint
116.3 - an example of the radio frequency of the VOR concerned
147° - an example of the VOR bearing to the nearest degree, which shall be indicated at the VOR checkpoint
4.3 NM - an example of the distance in nautical miles to a DME collocated with the VOR concerned.

Note: Tolerances for the bearing value indicated on the sign are specified in Annex 10, Volume I, Attachment E. It should be noted that a checkpoint can be used operationally only if periodic checks consistently show it to be within 2 degrees of the stated bearing.

Source: ICAO Annex 14 Volume 1

191.253 Aerodrome identification sign

(a) An aerodrome identification sign shall be provided at aerodromes with insufficient alternative means of visual identification.

(b) To the greatest extent possible, the aerodrome identification sign shall be placed on the aerodrome to be legible from all angles above the horizontal.

(c) The aerodrome identification sign shall bear the name of the aerodrome.

(d) The colour of the sign shall be sufficiently noticeable when viewed against its background.

(e) The characters shall be at least 3 metres tall.

191.255 Aircraft stand identification signs

(a) Where possible, an aircraft stand identification marking shall be accompanied by an aircraft stand identification sign.

(b) An identification sign for the aircraft stand shall be placed so that it is easily seen from the cockpit of the aircraft before entering.

(c) An identification sign for an aircraft stand shall consist of a black inscription on a yellow background.

191.257 Road-holding position sign

(a) A road-holding position sign shall be provided at each road entrance to a runway.

(b) The road-holding position sign shall be placed 1.5 metres from one edge of the road (left or right, depending on local traffic requirements) at the holding position.

(c) A road-holding position sign shall have white lettering on a red background.

(d) The following shall be included in the inscription of a road-holding position sign:

(1) a requirement to stop; and

(2) as applicable, a requirement to get ATC clearance and a location identifier.

Note: Aerodrome Design Manual (Doc 9157) Part 4 provides examples of road-holding position signals.

(e) A road-holding position sign designed for use at night shall be retroreflective or lighted.

Subpart M – Markers

191.261 General information

Markers shall be frangible. Those situated close to a runway or taxiway shall be sufficiently low to maintain propeller and jet engine pod clearance.

Note 1: Sometimes anchors or chains are used to prevent broken marks from being blown away by the wind.

Note 2: Guidance on the frangibility of markers is provided in OTAC 191-1.

191.263 Unpaved runway edge markers

(a) When the appearance of an unpaved surface of the runway contrasted with the surrounding ground does not clearly show the length of the runway, it is necessary to install markers.

(b) Where runway lighting is available, runway markings shall be included in the light fixtures. Where there are no lights, flat rectangular or conical markers shall be put to demarcate the runway.

(c) The rectangular markings shall have a minimum size of 1 m by 3 m and be positioned with their long dimension parallel to the runway centre line. The conical markers shall not exceed 50 cm in height.

191.265 Stopway edge markers

(a) Stopway edge markers shall be installed when the extent of a stopway cannot be determined by its appearance compared to the surrounding ground.

(b) The stopway edge markers shall be sufficiently distinct from any runway edge markers to prevent confusion between the two types of markers.

Note: Markers consisting of small vertical boards with a camouflaged reverse side, as observed from the runway, have proven to be operationally satisfactory.

191.267 Taxiway edge markers

(a) Taxiway edge markers shall 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.

(b) Taxiway edge markers shall be installed in the same locations as taxiway edge lights if they are used.

(c) A taxiway edge marker shall be blue and retroreflective.

(d) The pilot view of the marked surface shall be a rectangle with a minimum viewing area of 150 cm2.

(e) Taxiway edge markings shall be frangible. Their height shall be low enough to maintain adequate clearance for propellers and jet engine pods.

191.269 Taxiway centre line markers

(a) Taxiway centre line markers shall be provided on taxiways with code numbers 1 or 2 that do not have taxiway centre line, edge lights, or taxiway edge markers.

(b) Taxiway centre line markers shall be installed on taxiways with code numbers 3 or 4, and taxiway centre line lights shall be installed if there is a need to improve the guidance provided by taxiway centre line marking.

(c) Taxiway centre line markers shall be installed in the same location as taxiway centre line lights if used.

Note: The spacing of taxiway centre line lights is specified in OTAR 191.223 (m).

(d) Taxiway centre line markers shall be situated on the taxiway centre line marking unless it is impractical. In such cases, they shall be offset by no more than 30 cm

(e) A taxiway centre line marker shall be green and retroreflective.

(f) The marked surface shall be a rectangle with a minimum viewing area of 20 cm2, as seen by the pilot.

(g) Taxiway centre line markers shall be constructed and installed to withstand being run over by aircraft wheels without causing damage to either the aircraft or the markers.

191.271 Unpaved taxiway edge markers

(a) Markers shall be provided where the extent of an unpaved taxiway is not indicated by its appearance compared to the surrounding terrain.

(b) The markers shall be integrated into the light fixtures provided by taxiway lights. Conical-shaped markers shall be placed where there are no lights to delimit the taxiway.

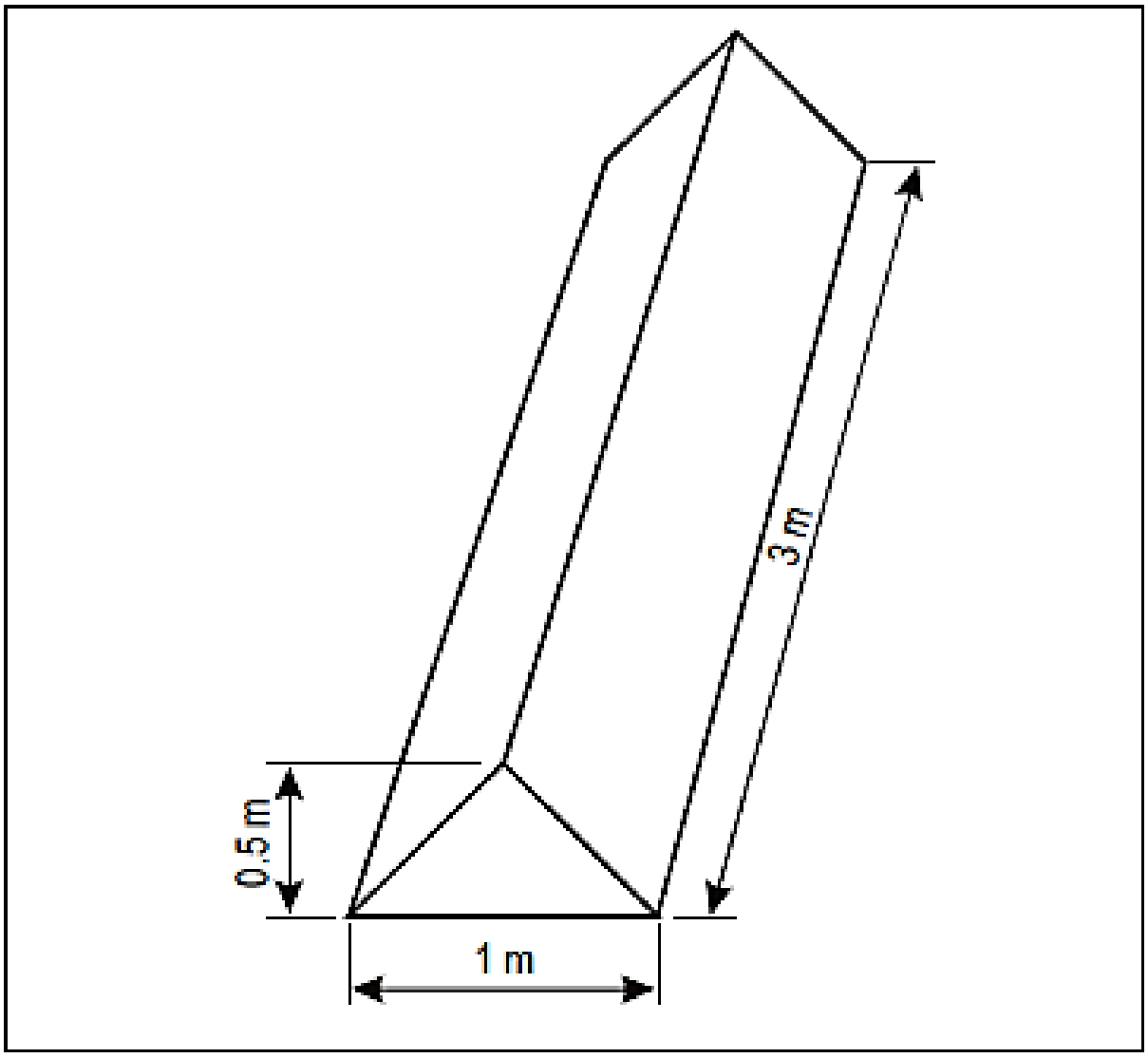
191.273 Boundary markers

(a) Boundary markings shall be provided when there is no runway in the landing location.

(b) The distance between boundary markers along the perimeter of the landing area shall not exceed 200 metres if the type depicted in Figure 42 is utilised or about 90 metres if the conical type is used with a marker at any corner.

(c) Boundary markers shall resemble those in Figure 42 or take the shape of a cone at least 50 cm tall and 75 cm in diameter at the base. The markers shall be coloured to stand out against the background on which they will be seen. It is best to use a single colour, such as orange or red, or two contrasting colours, such as orange and white or red and white unless those colours blend into the background.

Figure 42: Boundary markers



Source: ICAO Annex 14 Volume 1

Subpart N – Visual aids for denoting obstacles

Making obstacles visible, marking and/or lighting them is intended to reduce the risk to aircraft however, thismay not always reduce the operating restrictions that an obstacle may impose.

To limit the amount of light that local residents are exposed to, an autonomous aircraft detection system may be installed on or close to an obstacle (or group of obstacles, such as wind farms), with the lighting being activated only when the system detects an aircraft approaching the obstacle. The Aerodrome Design Manual (Doc 9157), Part 4, provides instructions on designing and installing an autonomous aircraft detection system. It is not intended that the availability of such guidance implies that such a system shall be provided.

191.279 Objects within the lateral boundaries of the obstacle limitation surfaces

(a) Vehicles and other mobile objects, excluding aircraft, in the movement area of an aerodrome are obstacles. They shall be marked and illuminated if the vehicles and aerodrome are used at night or in conditions of low visibility. Exceptions for aircraft servicing equipment and vehicles used only on aprons may be made.

(b) The daytime visibility of elevated aeronautical ground lights within the movement area shall be marked. Obstruction lights shall not be mounted on high ground lights or signs in the movement area.

(c) All obstacles within the distance specified in the eleventh and twelfth columns of Table 6 from the centre line of a taxiway, an apron taxiway, or an aircraft stand taxilane shall be marked, and if the taxiway, apron taxiway, or aircraft stand taxilane is utilised at night, illuminated.

(d) A fixed obstacle that extends above a take-off climb surface within 3 000 m of the inner edge of the take-off climb surface shall be marked and, if the runway is used at night, lighted, with the following exceptions:

(1) such marking and lighting may be omitted if another fixed obstacle shields the obstacle,

(2) the marking may be omitted if 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,

(3) the marking may be omitted if high-intensity obstacle lights light the obstacle by day; and

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

(e) A fixed object, other than an obstacle, adjacent to a take-off climb surface shall be marked and, if the runway is used at night, lighted, if such marking and lighting are deemed necessary to ensure its avoidance, with the following exceptions:

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

(2) high-intensity obstacle lights by day light the object.

(f) A fixed obstacle that extends above an approach surface within 3 000 m of the inner edge or above a transitional surface shall be marked and, if the runway is used at night, illuminated, with the following exceptions:

(1) such marking and lighting may be omitted when another fixed obstacle shields the obstacle,

(2) 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,

(3) the marking may be omitted when high-intensity obstacle lights light the obstacle by day; and

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

(g) A fixed obstacle that extends above a horizontal surface shall be marked and, if the aerodrome is used at night, lighted, except that:

(a) such marking and lighting may be omitted when:

(1) another fixed obstacle shields the obstacle,

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

(3) an aeronautical study demonstrates that the obstacle is not operationally significant.

(b) the marking may be omitted if Type A medium-intensity obstacle lights illuminate the obstacle during the day and its height above the surrounding ground does not exceed 150 m,

(c) when high-intensity obstacle lights illuminate the obstacle during the day, the marking may be omitted; and

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

(h) A fixed object that extends above an obstacle protection surface shall be marked and illuminated if the runway is used at night.

Note: For more information on the obstacle protection surface, see OTAR 191.197.

(i) Other objects within the obstacle limitation surfaces shall be marked and/or illuminated if an aeronautical study indicates that they could pose a hazard to aircraft (this includes objects adjacent to visual routes, such as a waterway or highway).

Note: See the note associated with OTAR 191.1274 (a).

(j) Overhead wires, cables, and other structures crossing a river, waterway, valley, or highway shall be marked and illuminated. Their supporting towers shall be marked and illuminated if an aeronautical study indicates that the wires or cables could pose a hazard to aircraft.

191.281 Objects outside the lateral boundaries of the obstacle limitation surfaces

(a) Obstacles shall be marked and lighted in accordance with OTAR 191.127 (b), except when high-intensity obstacle lights illuminate the obstacle during the day.

(b) Other objects outside the obstacle limitation surfaces shall be marked and/or illuminated if an aeronautical study indicates that they could pose a hazard to aircraft (this includes objects adjacent to visual routes, such as a waterway or highway).

(c) Overhead wires, cables, and other structures crossing a river, waterway, valley, or highway shall be marked and illuminated. Their supporting towers shall be marked and illuminated if an aeronautical study indicates that the wires or cables could pose a hazard to aircraft.

191.283 Marking and/or lighting of objects

(a) Low, medium or high-intensity obstacle lights, or a combination of such lights, shall indicate the presence of objects that shall be lit, as specified in OTAR 191.283.

(b) Low-intensity obstacle lights (Types A, B, C, D, and E), medium-intensity obstacle lights (Types A, B, and C), and high-intensity obstacle lights (Types A and B) shall meet the specifications in Table 16 and Appendix A.

(c) At each level to be marked, the number and arrangement of low, medium, or high-intensity obstacle lights shall be such that the object is visible from every azimuth angle. When a light is shielded in any direction by another part of the object or by an adjacent object, additional lights shall be provided on that adjacent object or the part of the object shielding the light in such a way that the general definition of the object to be lit is maintained. If the shielded light does not help define the object to be illuminated, it may be omitted.

191.285 Mobile objects

(a) All mobile objects that shall be marked shall be painted or display flags.

(b) When marking mobile objects with colour, a single conspicuous colour, preferably red or yellowish green for emergency vehicles and yellow for service vehicles shall be used.

(c) Flags used to identify mobile objects shall be displayed around, on top of, or around the highest edge of the object. Flags shall not add to the danger posed by the object they mark.

(d) Flags used to mark mobile objects shall be at least 0.9 m on each side and have a chequered pattern, with each square having sides of at least 0.3 m. The colours of the pattern shall contrast with one another and the background against which they will be seen. Except where such colours merge with the background, orange and white or red and white shall be used.

(e) Type C low-intensity obstacle lights shall be displayed on vehicles and mobile objects other than aircraft.

Note: See ICAO Annex 2 for information on aircraft lights.

(f) Low-intensity obstacle lights, Type C, displayed on emergency or security vehicles shall be flashing blue, while those displayed on other vehicles shall be flashing yellow.

(g) Type D low-intensity obstacle lights shall be displayed on follow-me vehicles.

(h) Low-intensity obstacle lights on objects with limited mobility, such as aerobridges, shall be fixed-red and meet the specifications for Type A low-intensity obstacle lights in Table 16. The intensity of the lights shall be sufficient to ensure conspicuity when compared to the intensity of adjacent lights and the general levels of illumination against which they are normally viewed.

Table 16: Characteristics of obstacle lights

Light Type	Colour	Signal type/ (flash rate)	Peak intensity(cd) at given Background Luminance[b]			Light Distribution Table
			Day (Above 500 cd/m2)	Twilight (50-500 cd/m2)	Night (Below 50 cd/m2)	
Low-intensity, Type A (fixed obstacle)	Red	Fixed	N/A	N/A	10	Table 17
Low-intensity, Type B (fixed obstacle)	Red	Fixed	N/A	N/A	32	Table 17
Low-intensity, Type C (mobile obstacle)	Yellow/Blue[a]	Flashing (60-90 fpm)	N/A	40	40	Table 17
Low-intensity, Type D (follow-me vehicle)	Yellow	Flashing (60-90 fpm)	N/A	200	200	Table 17
Low-intensity, Type E	Red	Flashing[c]	N/A	N/A	32	Table 17 (Type B)
Medium-intensity, Type A	White	Flashing (20–60 fpm)	20 000	20 000	2 000	Table 18
Medium-intensity, Type B	Red	Flashing (20–60 fpm)	N/A	N/A	2 000	Table 18
Medium-intensity, Type C	Red	Fixed	N/A	N/A	2 000	Table 18
High-intensity, Type A	White	Flashing (40–60 fpm)	200 000	20 000	2 000	Table 18
High-intensity, Type B	White	Flashing (40–60 fpm)	100 000	20 000	2 000	Table 18

[a] See OTAR 191.293 (f)
[b] Effective intensity for flashing lights as determined by the Aerodrome Design Manual (Doc 9157), Part 4
[c] For wind turbine application, to flash at the same rate as the lighting on the nacelle.

Table 17: Light distribution for low-intensity obstacle lights

	Minimum intensity[a]	Maximum intensity[a]	Vertical beam spread[f]	
			Minimum beam spread	Intensity
Type A	10 cd[b]	N/A	10°	5 cd
Type B	32 cd[b]	N/A	10°	16 cd
Type C	40 cd[b]	400 cd	12°[d]	20 cd
Type D	200 cd[b]	400 cd	N/A[e]	N/A

Note: This table does not include horizontal beam spread recommendations. OTAR 191.287 (c) requires 360-degree coverage of an obstruction. Consequently, the number of lights required to achieve this will depend on the horizontal beam spreads of each light and the geometry of the obstruction. Thus, narrower beam spreads will necessitate greater illumination.

[a] 360° horizontal. For flashing lights, the intensity is converted to the effective intensity in accordance with Part 4 of the Aerodrome Design Manual (Doc 9157).
[b] Between 2 and 20° vertical. When light is levelled, vertical elevation angles are related to the horizontal.
[c] Between 2 and 20° vertical. When light is levelled, vertical elevation angles are related to the horizontal
[d] Peak intensity shall be located at approximately 2.5° vertical.
[e] Peak intensity shall be located at approximately 17° vertical.
[d] Beam spread is defined as the angle between the horizontal plane and the directions in which the intensity is greater than what is listed in the "intensity" column.

Table 18: Light distribution for medium- and high-intensity obstacle lights according to benchmark intensities of Table 16

Benchmark intensity	Minimum requirements					Recommendations				
	Vertical elevation angle (b)			Vertical beam spread[c]		Vertical elevation angle[b]			Vertical beam spread[c]	
	0°		-1°			0°	-1°	-10°		
	Minimum average intensity[a]	Minimum Intensity[a]	Minimum Intensity[a]	Minimum beam spread	Intensity[a]	Maximum intensity[a]	Maximum intensity[a]	Maximum Intensity[a]	Maximum beam spread	Intensity[a]
200 000	200 000	150 000	75 000	3°	75 000	250 000	112 500	7 500	7°	75 000
100 000	100 000	75 000	37 500	3°	37 500	125 000	56 250	3 750	7°	37 500
20 000	20 000	15 000	7 500	3°	7 500	25 000	11 250	750	N/A	N/A
2 000	2 000	1 500	750	3°	750	2 500	1 125	75	N/A	N/A

Note: This table does not include horizontal beam spread recommendations. OTAR 191.287 (c) requires 360-degree coverage of an obstruction. Consequently, the number of lights required to achieve this will depend on the horizontal beam spreads of each light and the geometry of the obstruction. Thus, narrower beam spreads will necessitate greater illumination
a Horizontal 360° Candela is used to express all intensities. The intensity of flashing lights is converted to effective intensity in accordance with Part 4 of the Aerodrome Design Manual (Doc 9157).
b When the light unit is levelled, the vertical elevation angles are referenced to the horizontal.
c Beam spread is defined as the angle formed by the horizontal plane and the directions whose intensity is greater than that specified in the "intensity" column

Note: In some cases, an increased beam spread may be required and supported by an aeronautical analysis.

191.287 Fixed objects

(a) All fixed objects to be marked shall be coloured wherever possible. If this is impossible, markers or flags shall be displayed on or above them, except for things that are sufficiently apparent by their shape, size, or colour.

Note: Wind turbine fixed objects are addressed individually in OTAR 191.293, and overhead wires, cables, and other fixed objects, as well as supporting towers, are addressed separately in OTAR 191.295.

(b) If an object has largely unbroken surfaces and its projection on any vertical plane equals or exceeds 4.5 m in both dimensions, it shall be coloured to exhibit a chequered pattern. The pattern shall be made up of rectangles measuring 1.5 to 3 metres on each side, with a darker colour at the corners. The colours of the pattern shall contrast one another and the background against which they will be visible. Except where such colours blend with the background, orange and white or red and white shall be utilised. (See Figure 43).

(c) An object shall be coloured to show alternating contrasting bands if:

(1) has essentially unbroken surfaces and one horizontal or vertical dimension greater than 1.5 m and the other horizontal or vertical dimension less than 4.5 m; or

(2) it is of skeletal type with either a vertical or horizontal dimension greater than 1.5 m.

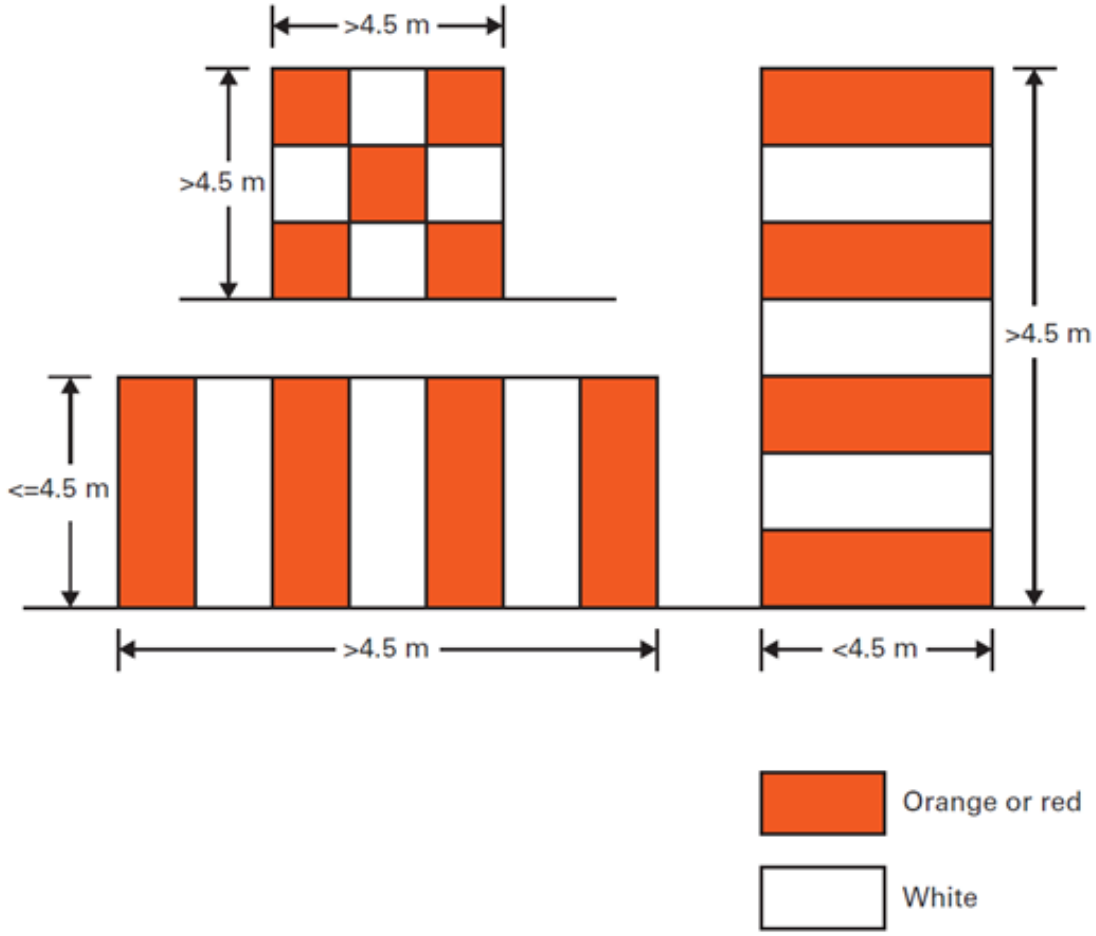
(d) The bands shall be perpendicular to the longest dimension and 1/7 of the width of the longest dimension, or 30 metres, whichever is smaller. The colours of the bands shall contrast with the background they will be visible against. If such colours are not apparent against the background, orange and white shall be employed. The darker colour shall be used for the bands on the extremities of the object. (See Figures 43 and 44 for details.)

Note: Table 19 presents a formula for determining band widths and having an odd number of bands, allowing the darker colour to be used on both the top and bottom bands.

(e) If the projection of an object on any vertical plane has both dimensions less than 1.5 m, it shall be coloured in a single noticeable colour. If such colours blend with the background, orange or red shall be used.

Note: To achieve sufficient contrast against particular backdrops, it may be required to choose a colour other than orange or red.

Figure 43: Basic marking patterns



Source: CAP168

Table 19: Marking band widths

Longest dimension		
Greater than	Not exceeding	**Band width**
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

(f) Flags used to mark fixed objects shall be displayed around, on top of, or around the highest edge of the object. Flags shall be displayed at least every 15 metres when used to mark large objects or groups of closely spaced objects. Flags shall not increase the hazard posed by the object they mark. The minimum size for flags designating fixed objects shall be not less than 0.6 metres on each side.

(g) Flags used to mark fixed objects shall be orange or a mixture of two triangular parts, one orange and the other white, or one red and the other white, unless such colours blend with the background, in which case alternative conspicuous colours shall be used.

(h) Markers displayed on or adjacent to objects shall be placed in conspicuous positions to preserve the general definition of the object. They shall be recognisable in clear weather from a minimum distance of 1 000 m for an object to be viewed from the air and 300 m for an object to be viewed from the ground in all directions from which an aircraft is likely to approach the object. The shape of markers shall be different enough to prevent them from being confused with other markers, and they shall not enhance the hazard posed by the thing they identify.

(i) A marker shall be a single colour. The chosen colour shall contrast with the background against which it will be viewed. When installed, alternate white and red or white and orange markers shall be displayed.

(j) If an object is illuminated, one or more low-, medium-, or high-intensity obstacle lights shall be situated as close to the top of the object as is practically possible.

Note: Appendix E provides recommendations for displaying a combination of low, medium, and/or high-intensity lights on obstacles.

(k) In the case of a chimney or other structure with a similar function, the top lights shall be positioned far enough below the apex to prevent contamination by smoke, etc. (See Figure 45).

(l) If a high-intensity obstacle light is not practicable to locate on the top of a tower or antenna structure with an appurtenance greater than 12 m, such as a rod or an antenna, such light shall be located at the highest possible point and, if practicable, a medium-intensity obstacle light, Type A, mounted on the top.

(m) In the case of an extensive object or a group of closely spaced objects to be lighted that are:

(1) penetrating a horizontal obstacle limitation surface (OLS) or located outside an OLS, the top lights shall be arranged to at least indicate the points or edges of the object highest in relation to the obstacle limitation surface or above the ground and to indicate the general definition and extent of the objects; and

(2) penetrating a sloping OLS, the top lights shall be arranged to at least indicate the points or edges of the object highest in relation to the OLS and the general definition and extent of the objects. If two or more edges are of the same height, the edge nearest the landing area shall be marked.

(n) Additional obstacle lights shall be put on the highest point of the item when the obstacle limiting surface is sloping, and the highest point above the OLS is not the highest point of the object.

(o) When lights display the definition of an extensive object or a group of closely spaced objects, they shall be spaced at longitudinal intervals of not more than 45 m for low-intensity lights and 900 m for medium-intensity lights.

(p) Type A high-intensity obstacle lights and Types A and B medium-intensity obstacle lights on an item shall both flash at the same time.

(q) The installation setup angles for Type A high-intensity obstacle lights shall follow Table 21.

Note: High-intensity obstacle lights can be used both day and night. It is important to avoid creating distracting glare with these lights. The Aerodrome Design Manual (Doc 9157), Part 4, provides guidance on the design, positioning, and operation of high-intensity obstacle lights.

(r) A dual obstacle lighting system shall be provided where, in the opinion of the Governor, 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. For daytime and twilight use, this system shall include high-intensity obstacle lights, Type A or medium-intensity obstacle lights, Type A, as appropriate, and medium-intensity obstacle lights, Type B or C, for night-time use.

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

(1) Where the object is less extensive, and its height above the surrounding ground is less than 45 metres, low-intensity obstacle lights, Type A or B, shall be used.

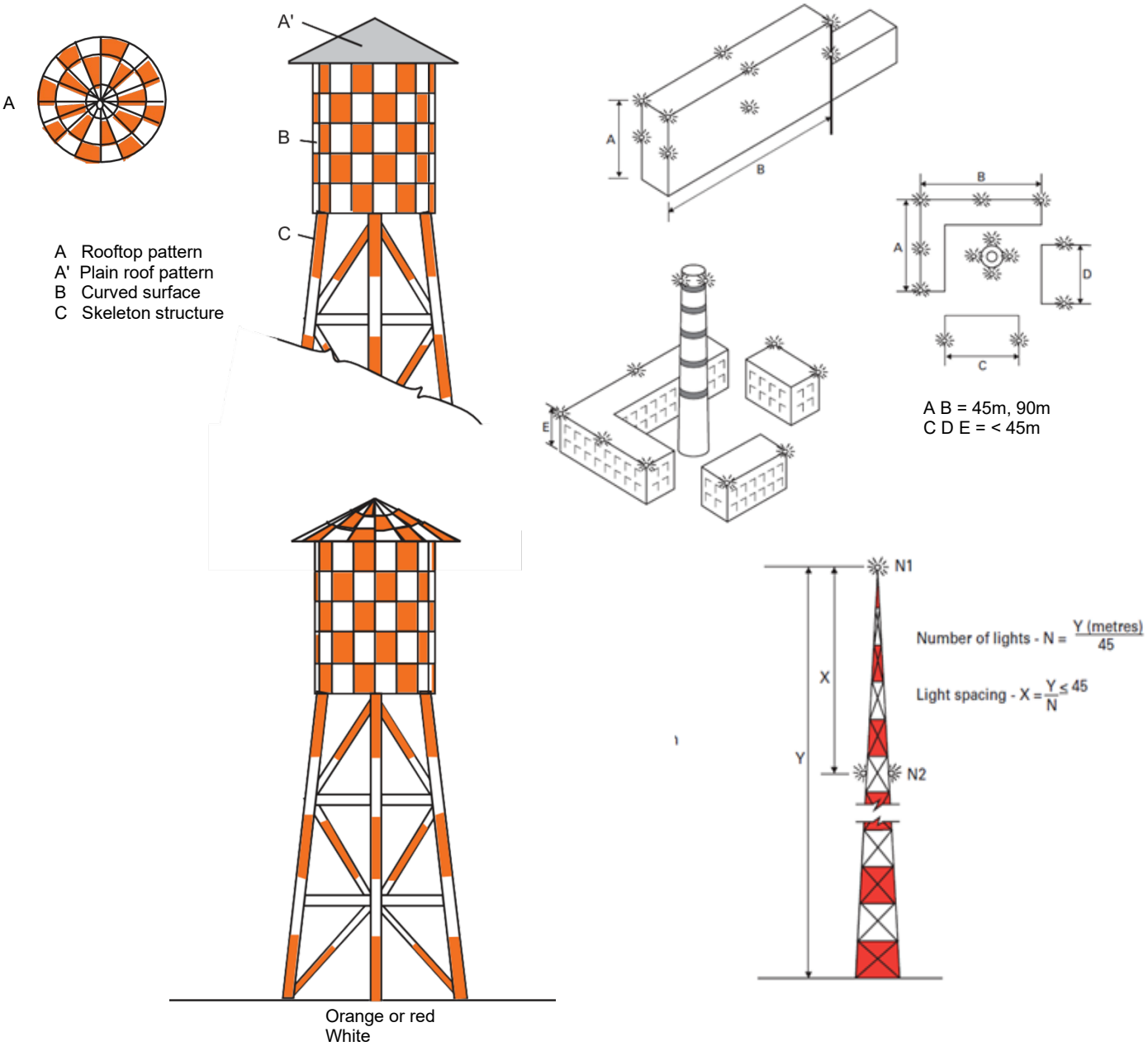
(2) Medium- or high-intensity obstacle lights shall be utilised when low-intensity obstacle lights, Type A or B, are insufficient or an early special warning is required.

(3) According to OTAR 191.291 (t) (1), low-intensity obstacle lights, Type B, shall be used alone or in combination with medium-intensity obstacle lights, Type B.

(4) Medium-intensity obstacle lights (Type A, B, or C) shall be employed where the object is large. Types A and C medium-intensity obstacle lights shall be used alone. Still, Type B medium-intensity obstacle lights shall be used alone or in combination with Type B low-intensity obstacle lights.

Note: A group of buildings is regarded as an extensive object

Figure 44: Examples of marking and lighting of tall structures



Source: CAP168

Source: ICAO Annex 14 Volume 1

(t) Lighting of objects with a height of 45 m to a height less than 150 m above ground level:

(1) Type A, B, or C medium-intensity obstacle lights shall be utilised. Medium-intensity obstacle lights, Types A and C, shall be used alone. In contrast, medium-intensity obstacle lights, Type B, may be used alone or in conjunction with low-intensity obstacle lights, Type B.

(2) Where an object is indicated by medium-intensity obstacle lights, Type A, and its top is more than 105 m above the surrounding ground or the elevation of neighbouring buildings (when buildings surround the object to be marked), additional lights shall be placed at intermediate levels. The spacing between these additional intermediate lights and the ground level or the level of the tops of neighbouring buildings shall not exceed 105 metres.

(3) When an object is indicated by medium-intensity obstacle lights, Type B, and its top is more than 45 m above the surrounding ground or the elevation of nearby buildings (when buildings surround the object to be marked), additional lights shall be provided at intermediate levels. These additional intermediate lights shall alternate between low-intensity obstacle lights, Type B, and medium-intensity obstacle lights, Type B, and shall be spaced as equally as practicable between the top lights and ground level or the level of the tops of nearby buildings, as applicable, with a maximum separation of 52 metres.

(4) When an object is indicated by medium-intensity obstacle lights, Type C, and the top is more than 45 m above the surrounding ground or the elevation of nearby buildings (when buildings surround the object to be marked), additional lights are required at intermediate levels. These additional intermediate lights shall be spaced as evenly as practicable between the top lights and ground level or the level of the tops of nearby buildings, as applicable, with a maximum distance of 52 metres between each pair.

(5) When Type A high-intensity obstacle lights are used, they shall be spaced at uniform intervals not exceeding 105 m between the ground level and the top light(s) specified in OTAR 191.291 (k); however, if the object to be marked is surrounded by buildings, the tops of the buildings may be used as the equivalent of the ground level when determining the number of light levels.

(u) Lighting of objects with a height of 150 m or more above ground level:

(1) High-intensity obstacle lights, Type A, shall indicate the presence of an object if its height above the surrounding ground level exceeds 150 m. An aeronautical study determines that such lights are necessary for the daytime recognition of the object.

(2) When Type A high-intensity obstacle lights are used, they shall be spaced at uniform intervals not exceeding 105 m between the ground level and the top light(s) specified in OTAR 191.291 (k); however, if the object to be marked is surrounded by buildings, the tops of the buildings may be used as the equivalent of the ground level when determining the number of light levels.

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

(4) When medium-intensity obstacle lights indicate an object, Type A, intermediate-level lights shall be provided. The spacing between these additional intermediate lights and the ground level or the level of the tops of nearby buildings shall not exceed 105 metres.

(5) When medium-intensity obstacle lights, Type B indicate an object, intermediate-level lights shall be provided. These additional intermediate lights shall alternate between low-intensity obstacle lights, Type B, and medium-intensity obstacle lights, Type B, and shall be spaced as equally as practicable between the top lights and ground level or the level of the tops of nearby buildings, as applicable, with a maximum separation of 52 metres.

(6) When medium-intensity obstacle lights indicate an object, Type C, intermediate-level lights shall be provided. These additional intermediate lights shall be spaced as evenly as practicable between the top lights and ground level or the level of the tops of nearby buildings, as applicable, with a maximum distance of 52 metres between each pair.

191.289 Wind turbines

(a) A wind turbine shall be marked and/or illuminated if it is deemed an obstruction.

Note 1: Whenever the Governor deems necessary, additional lighting or markings may be installed.

Note 2: See OTAR 191.127 (a) and (b)

(b) The rotor blades, nacelle, and upper two-thirds of the supporting mast of wind turbines shall be painted white unless an aeronautical study indicates otherwise.

(c) When lighting is deemed necessary for a wind farm, which is a collection of two or more wind turbines, the wind farm shall be considered a large object, and the following lighting shall be installed:

(1) to identify the perimeter of the wind farm,

(2) respecting the maximum spacing, in accordance with OTAR 191.291 (p), between the lights along the perimeter, unless a dedicated assessment demonstrates that a greater spacing can be used,

(3) so that, where flashing lights are used, they flash simultaneously throughout the wind farm,

(4) so that, within a wind farm, any wind turbines of significantly higher elevation are also identified wherever they are located; and

(5) at locations specified in OTAR 191.293 (c) (1), (2), and (4), according to the following standards:

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

(ii) for wind turbines between 150 m and 315 m in overall height, in addition to the medium-intensity light installed on the nacelle, a second light serving as a backup shall be installed in case the operating light fails.

(iii) additionally, for wind turbines between 150 m and 315 m in overall height, an intermediate level containing at least three low-intensity Type E lights, as specified in OTAR 191.287 (c), shall be provided at half the nacelle height. If an aeronautical study determines that low-intensity Type E lights are unsuitable, low-intensity Type A or Type B lights may be used instead.

Note: OTAR 191.293 (c) (5) does not apply to wind turbines taller than 315 metres. Depending on the results of an aeronautical study, additional marking and lighting may be required for these wind turbines.

(d) The obstacle lights shall be installed on the nacelle so that aircraft approaching from any direction have an unobstructed view.

(e) If lighting is deemed necessary for a single wind turbine or short line of wind turbines, the installation shall comply with OTAR 191.293 (c) (5) or be determined by an aeronautical study.

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

(a) The to-be-marked wires, cables, etc., shall be provided with markers, and the tower shall be coloured.

(b) The supporting towers of overhead wires, cables, etc., that require marking shall be marked in accordance with 191.291 (a) to (e), except where high-intensity obstacle lights illuminate them during the day, in which case labelling may be avoided.

(c) Markers displayed on or adjacent to objects shall be placed in conspicuous positions to preserve the general definition of the object. They shall be recognisable in clear weather from a minimum distance of 1 000 m for an object to be viewed from the air and 300 m for an object to be viewed from the ground in all directions from which an aircraft is likely to approach the object. The shape of markers shall be different enough to prevent them from being confused with other markers, and they shall not enhance the hazard posed by the object they identify.

(d) A marker displayed on an overhead wire, cable, etc., shall be spherical and not less than 60 cm in diameter.

(e) The distance between consecutive markers or between a marker and a supporting tower shall be proportional to the diameter of the marker but shall never exceed:

(1) 30 m for markers with a diameter of 60 cm,

(2) 35 m for markers with a diameter of 80 cm; and

(3) 40 m for markers with a diameter of at least 130 cm.

(f) In situations involving several wires, cables, etc., a marker shall be placed no lower than the level of the tallest wire at the indicated spot.

(g) A marker shall be a single hue. When installed, alternate white and red or white and orange markers shall be displayed. The chosen colour shall contrast with the background against which it will be viewed.

(h) When it has been decided that an overhead wire, cable, etc. requires marking, but it is impractical to install markers on the wire, cable, etc., Type B high-intensity obstacle lights shall be installed on their supporting towers.

(i) High-intensity obstacle lights, Type B, shall be used to indicate the presence of a tower supporting overhead wires, cables, etc., when:

(1) an aeronautical study indicates that such lights are essential for recognising the presence of wires, cables, etc.; or

(2) it has not been determined to be feasible to install markers on the wires, cables, etc.

(j) When Type B high-intensity obstacle lights are employed, they shall be positioned at three levels: at the top of the tower, at the lowest level of the wires or cables' catenary, and approximately in the middle of these two levels.

Note: In some instances, this may necessitate situating the lights away from the tower.

(k) High-intensity obstacle lights Type B that indicate the existence of a tower supporting wires, cables, etc., shall flash sequentially: first, the middle light, then the top light, and finally, the bottom light. The durations between light flashes are described in Table 20.

Table 20: Ratios of the intervals between flashes of the lights

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

Note: High-intensity obstacle lights are designed for daytime and night-time application. It is necessary to ensure that these lights do not cause distracting glare. Part 4 of the Aerodrome Design Manual (Doc 9157) provides guidelines for designing, operating, and placing high-intensity obstacle lights.

(l) A dual obstacle lighting system shall be provided where, in the opinion of the Governor, the use of high-intensity obstacle lights, Type B, at night may dazzle pilots in the vicinity of an aerodrome (within approximately 10,000 m) or cause substantial environmental issues. This system shall include high-intensity Type B obstacle lights for daytime and twilight use and medium-intensity Type B obstacle lights for night-time use. Medium-intensity lights shall be installed at the same height as Type B high-intensity obstacle lights wherever they are used.

(m) The installation setting angles for Type B high-intensity obstacle lights shall conform to Table 21.

Table 21: 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	
151 m		0°
122 m	151 m	1°
92 m	122 m	2°
	92 m	3°

Subpart O – Visual aids for denoting restricted use areas

191.297 Closed runways and taxiways, or parts thereof

(a) A closed marking shall be placed on any runway, taxiway, or section permanently closed to all aircraft traffic.

(b) A closed marking shall be shown on a temporarily closed runway, taxiway, or portion thereof unless the temporary closure is of short duration and air traffic services provide enough warning.

(c) On a runway, a closed marking shall be posted at each end of the runway or segment of the runway that has been declared closed, and additional markings shall be placed so that the maximum distance between markings does not exceed 300 metres. On a taxiway, a closed marking shall be put at least at each end of the closed taxiway or taxiway segment.

(d) When exhibited on a runway, the closed marking shall be of the shape and proportions indicated in Figure 45. When displayed on a taxiway, the closed marking shall be of the form and proportions detailed in Figure 45. When exhibited on a runway, the marker shall be white, and when displayed on a taxiway, it shall be yellow.

Note 1: When an area is temporarily closed, frangible barriers, non-paint markings, or other suitable measures may be employed to demarcate the closed area.

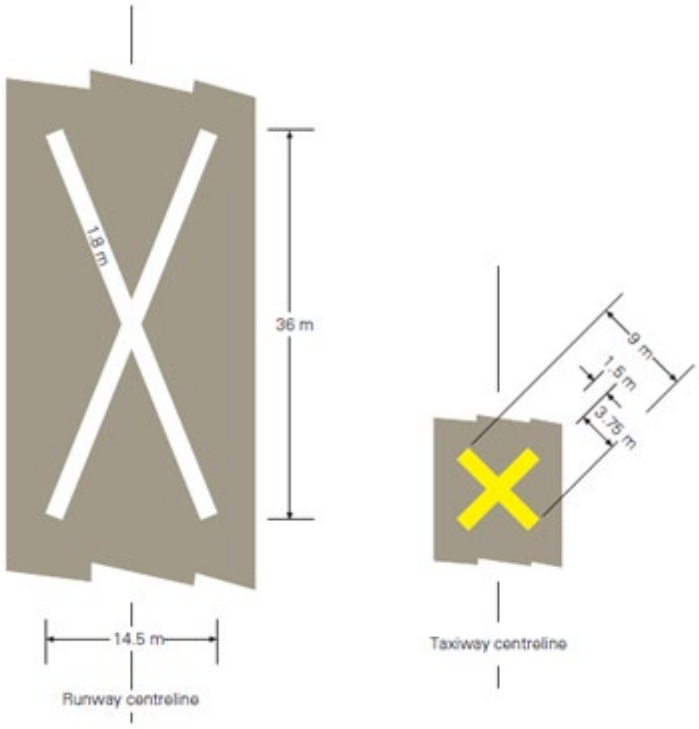
Note 2: The PANS-Aerodromes outlines the planning, coordination, monitoring, and safety management of ongoing construction on the movement area (Doc 9981).

(e) When a runway, taxiway, or portion thereof is permanently closed, all usual markings shall be removed.

(f) The lighting on a closed runway, taxiway, or section thereof shall not be operated unless maintenance is required.

(g) In addition to closed markers, when a closed runway, taxiway, or section thereof intersects a night-time useable runway or taxiway, unserviceability lights shall be installed across the entrance to the closed area at intervals no greater than 3 metres (see OTAR 191.307 (d)).

Figure 45: Closed runway and taxiway markings



Source: CAP 168

191.299 Non-load-bearing surfaces

(a) Shoulders for taxiways, runway turn pads, holding bays and aprons, and other non-load-bearing surfaces which cannot be readily distinguished from load-bearing surfaces and which, if used by aircraft, could cause damage to the aircraft, shall have a taxi side stripe marking delineating the boundary between such areas and the load-bearing surface.

Note: The marking of runway sides is specified in OTAR 191.157.

(b) A taxi side stripe marking shall be placed along the edge of the load-bearing pavement, with the outer edge of the marking approximately on the edge of the load-bearing pavement .

(c) A taxi side stripe marking shall consist of two 15-centimeter-wide, 15-centimeter-spaced, solid lines of the same colour as the taxiway centre line marking.

Note: Part 4 of the Aerodrome Design Manual (Doc 9157) provides information regarding the addition of transverse stripes at an intersection or in a small area of the apron.

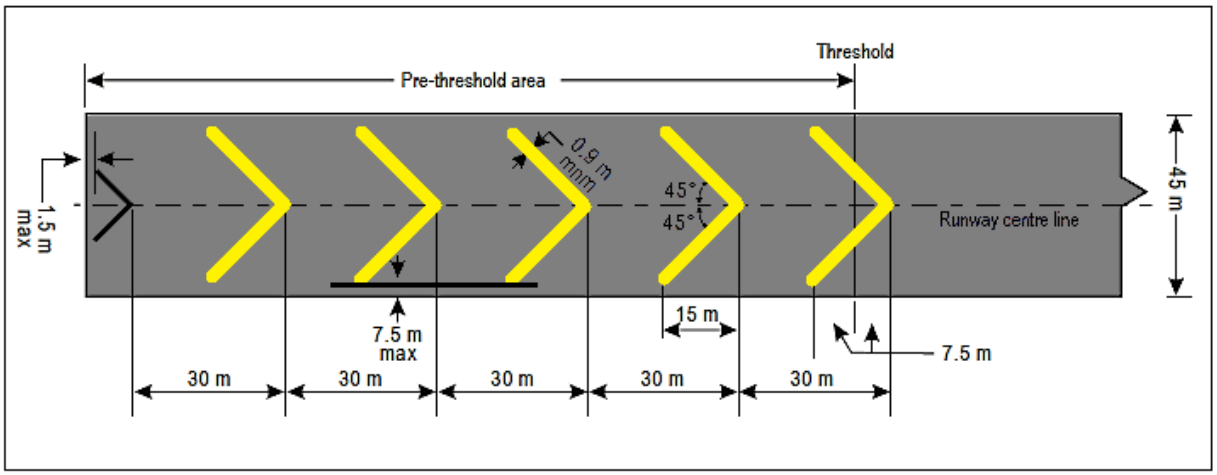
191.301 Pre-threshold area

(a) When the paved area before a threshold exceeds 60 metres in length and is not suitable for routine aircraft use, the full length shall be marked with chevrons.

(b) A chevron marking shall be installed, as depicted in Figure 46, pointing in the direction of the runway.

(c) A chevron marking shall be of a noticeable colour that contrasts with the colour used for the runway markers; yellow is the preferred colour. It shall have a minimum width of 0.90 metres.

Figure 39: Pre-threshold marking



191.303 Unserviceable areas

(a) Unserviceability markings shall be displayed whenever a piece of a taxiway, apron, or holding bay is unsuited for aircraft movement but may still be safely avoided. In a night-time mobility area, inoperable lights shall be utilised.

Note 1: Unserviceability signs and lights are utilised to alert pilots of a hole in a taxiway or apron pavement or to outline a part of the pavement, such as on an apron, that is undergoing maintenance. They cannot be utilised when a segment of a runway or taxiway becomes unusable, nor when a significant portion of the width of a taxiway becomes unusable. Typically, the runway or taxiway is closed in such situations.

Note 2: The PANS-Aerodromes outline the planning, coordination, monitoring, and safety management of ongoing construction on the movement area (Doc 9981).

(b) Unserviceability markings and lights shall be put at close enough intervals to define the unserviceable area clearly.

Note: OTAC 191-1 provides guidance on the location of unserviceability lights.

(c) Devices such as flags, cones, or marker boards that are visible and upright shall be used as unserviceability markings.

(d) A red fixed light shall be used as an unserviceability light. Compared to the intensity of surrounding lights and the ambient level of lighting against which it would normally be viewed, the light shall have an adequate intensity to ensure visibility. The intensity of the red light shall never be less than 10 cd.

(e) Unserviceability cones shall be at least 0.5 m tall and painted red, orange, yellow, or any combination of these colours and white.

(f) An unserviceability flag shall be at least 0.5 m square and made of red, orange, yellow, or any combination of these colours and white.

(g) An unserviceability marker board shall be at least 0.5 m tall and 0.9 m long, with vertical stripes that alternate between red and white or orange and white.

Subpart P – Electrical systems

191.309 Electrical power supply systems for air navigation facilities

(a) An adequate primary power supply is required at aerodromes to operate air navigation facilities safely.

(b) The design and provision of electrical power systems for airport visual and radio navigation aids shall ensure that an equipment breakdown does not leave the pilot with insufficient visual and non-visual guidance or false information.

Note: The design and installation of electrical systems must consider potential malfunction-causing elements, such as electromagnetic disturbances, line losses, power quality, etc. Aerodrome Design Manual (Doc 9157) Part 5 provides additional guidelines.

(c) Electric power supply connections to those facilities that require secondary power shall be configured so that the facilities are automatically connected to the secondary power source in the event of a breakdown of the primary power source.

(d) The time interval between the failure of the primary source of power and the full restoration of services required by OTAR 191.315 (e) shall be as brief as possible, except for visual aids associated with non-precision, precision approach or take-off runways, for which the requirements of Table 22 for maximum switch-over times shall apply.

Note: A definition of switch-over time is given in OTAR 191.11.

(e) Implementing a switch-over time definition shall not necessitate the replacement of an existing secondary power supply before January 1, 2010. However, for a secondary power supply established after 4 November 1999, the electric power supply connections to those facilities requiring secondary power shall be configured so that the facilities can meet the requirements of Table 22 for maximum switch-over times as defined in OTAR 191.11.

Note: The quality of the provided power determines the safety of airport operations. The whole electrical power supply system may consist of connections to one or more external sources of electric power supply, one or more local producing facilities, and a distribution network with transformers and switchgear. When planning the electrical power system for aerodromes, several other amenities supplied by the same system must be taken into consideration.

191.311 Electrical power supply systems for air visual aids

(a) A secondary power supply capable of meeting the requirements of Table 22 for the appropriate type of precision approach runway shall be provided for a precision approach runway. When the primary source of power fails, the electric power supply connections to those facilities that require secondary power shall be configured so that the facilities are automatically linked to the secondary power supply.

(b) A secondary power supply capable of meeting the relevant requirements of Table 22 shall be provided for a runway intended for take-off in RVR less than 800 m.

(c) A secondary power supply capable of meeting the requirements of Table 22 shall be provided at an aerodrome where the primary runway is a non-precision approach runway, except that a secondary power supply for visual aids does not need to be provided for more than one non-precision approach runway.

(d) A secondary power supply capable of meeting the requirements of OTAR 191.313 (d) shall be provided at an aerodrome where the primary runway is a non-instrument runway, except that a secondary power supply for visual aids is not required when an emergency lighting system in accordance with the specification of OTAR 191.185 is provided and capable of being deployed in 15 minutes.

(e) The following aerodrome facilities shall be equipped with a backup power source in case the primary power supply fails:

(1) the signalling lamp and the minimum lighting required for air traffic controllers to perform their duties,

Note: The minimum illumination requirement may be met by means other than electricity.

(2) all obstacle lights deemed necessary by the Governor to ensure the safe operation of aircraft,

(3) approach, runway, and taxiway lighting as specified in OTAR 191.315 (a) to (d),

(4) meteorological equipment,

(5) essential security lighting, if provided in accordance with OTAR 191.329,

(6) essential equipment and facilities for the aerodrome responding emergency agencies,

(7) floodlighting on a designated isolated aircraft parking position if provided in accordance with OTAR 191.237 (a); and

(8) illumination of apron areas over which passengers may walk.

Note: Specifications for secondary power supply for radio navigation aids and ground elements of communications systems are given in Annex 10, Volume I, Chapter 2.

(f) Requirements for a secondary power supply shall be met by either independent public power, which is a source of power supplying the aerodrome service from a substation other than the normal substation via a transmission line following a different route than the normal power supply route and such that the possibility of simultaneous failure of the normal and independent public power supplies is extremely remote; or standby power unit(s) which are engine generators, batteries, etc., from which electric power can be obtained.

Note: Part 5 of the Aerodrome Design Manual (Doc 9157) contains information on electrical systems.

Table 22: Secondary power supply requirements (See OTAR 191.313 (d))

Runway	Lighting aids requiring power	Maximum switch-over time
Non-instrument	Visual approach slope indicators[a] Runway edge[b] Runway threshold[b] Runway end[b] Obstacle[a]	See OTAR 191.313 (d) and OTAR 191.315 (d)
Non-precision approach	Approach lighting system Visual approach slope indicators[a, d] Runway edge[d] Runway threshold[d] Runway end Obstacle[a]	15 seconds 15 seconds 15 seconds 15 seconds 15 seconds 15 seconds
Precision approach category I	Approach lighting system Runway edged Visual approach slope indicators[a, d] Runway threshold[d] Runway end Essential taxiway[a] Obstacle[a]	15 seconds 15 seconds 15 seconds 15 seconds 15 seconds 15 seconds 15 seconds
Precision approach category II/III	Inner 300 m of the approach lighting system Other parts of the approach lighting system Obstacle[a] Runway edge Runway threshold Runway end Runway centre line Runway touchdown zone All stop bars Essential taxiway	1 second 15 seconds 15 seconds 15 seconds 1 second 1 second 1 second 1 second 1 second 15 seconds
Runway meant for take-off in RVR less than a value of 800 m	Runway edge Runway end Runway centre line All stop bars Essential taxiway[a] Obstacle[a]	15 seconds[c] 1 second 1 second 1 second 15 seconds 15 seconds

a. Supplied with secondary power when their operation is critical to flight safety.
b. For information on the use of emergency lighting, see OTAR 191.185.
c. One second when there are no runway centre line lights.
d. One second if the approach is over hazardous or steep terrain.

191.312 System design

(a) The electrical systems for power supply, lighting, and control of the lighting systems included in Table 22 for a runway intended for use in RVR less than 550 m shall be designed in such a way that an equipment failure will not leave the pilot with inadequate visual guidance or misleading information.

Note: The Aerodrome Design Manual (Doc 9157), Part 5, provides guidance on providing this protection.

(b) When duplicate feeders deliver the secondary power supply of an aerodrome, these supplies shall be physically and electrically distinct to ensure the appropriate level of availability and independence.

(c) When runway and taxiway illumination are provided on a runway that is part of a standard taxiway, the lighting systems shall be linked to prevent both types of lighting from operating simultaneously.

191.315 Monitoring

(a) A monitoring system shall be implemented to indicate the lighting systems' operational status.

Note: Guidance on monitoring can be found in Part 5 of the Aerodrome Design Manual (Doc 9157).

(b) When lighting systems are utilised for aircraft control, they shall be automatically monitored to offer a signal of any malfunction that could impair the control operations. This data shall be transmitted automatically to the air traffic services unit.

(c) Where there has been a change in the operational status of lights, an indication shall be delivered within two seconds for a stop bar at a runway holding position and within five seconds for all other forms of visual aids.

(d) The lighting systems detailed in Table 22 for a runway intended for use in RVR less than 550 m shall be monitored automatically to indicate when the serviceability level of any element falls below the minimum serviceability level specified in ICAO Annex 14 Volume 1 10.5.7 to 10.5.11, as appropriate. This information shall be sent to the maintenance team automatically.

(e) The lighting systems detailed in Table 22 for a runway intended for use in RVR less than 550 m shall be monitored automatically to indicate when the serviceability level of any element falls below the minimum level specified by the appropriate authority below which operations shall not continue. This data shall be automatically transmitted to the air traffic control unit and displayed prominently.

Note: The Aerodrome Design Manual (Doc 9157), Part 5 contains information on the air traffic control interface and visual aids monitoring.

Subpart Q – Aerodrome equipment installations

191.321 Siting of equipment and installations in operational areas

(a) No equipment or installation shall be on a runway strip, RESA, a taxiway strip, or within the distances specified in the eleventh column of Table 6 if it would endanger an aircraft; or on a clearway if it would endanger an aircraft in the air unless its function requires it to be there for air navigation or aircraft safety purposes.

(b) Any equipment or installation required for air navigation or aircraft safety that shall be located on the list below shall be frangible and mounted as low as possible:

(1) on a runway strip within 75 m of the runway centre line where the code number is 3 or 4; or 45 m of the runway centre line where the code number is 1 or 2; or

(2) on RESA, a taxiway strip, or within the distances specified in Table 6; or

(3) on a clearway and would endanger an aircraft in the air.

(c) Any equipment or installation essential for air navigation or aircraft safety that shall be positioned on the ungraded portion of a runway strip shall be considered an impediment and shall be frangible and mounted as low as practicable.

Note: Part 6 of the Aerodrome Design Manual (Doc 9157) provides guidelines for the placement of navigation aids.

(d) No equipment or installation shall be installed within 240 m of the end of the runway strip and within:

(1) 60 m of the extended centre line where the code number is 3 or 4; or

(2) 45 m of the extended centre line where the code number is 1 or 2;

of a precision approach runway category I, II, or III.

(e) Any equipment or installation that shall be installed on or near a strip of a precision approach runway category I, II, or III for air navigation or aviation safety considerations and that:

(1) is within 240 metres of the end of the strip and within: 60 metres of the extended runway centre line where the code number is 3 or 4; or 45 metres of the extended runway centre line where the code number is 1 or 2; or

(2) penetrates the inner approach surface, the inner transitional surface, or the baulked landing surface;

shall be frangible and mounted as low as possible.

(f) Any equipment or installation necessary for air navigation or aircraft safety that is an operationally significant impediment, as defined by OTAR 191.125 (b) (3), 191.125 (c) (4), 191.125 (d) (7), or 191.125 (e) (6), shall be frangible and mounted as low as practicable.

191.323 Fencing

(a) On an aerodrome, a fence or other suitable barrier shall be installed to prevent large animals that pose a threat to aircraft from entering the movement area.

(b) On an aerodrome, a fence or other suitable barrier shall be installed to prevent an unauthorised accidental or intentional entry of the individual onto a non-public part of the aerodrome.

Note 1: This is intended to include the barricading of sewers, ducts, tunnels, etc., when required to prevent access.

Note 2: Special measures may be necessary to prevent unlawful access to runways or taxiways that pass over public roadways.

(c) Off-airport ground infrastructure and facilities vital for civil aviation safety shall be protected against accidental or deliberate access by unauthorised individuals.

(d) The fence or barrier shall be positioned to separate the movement area and other facilities or zones in the airport that are essential to the safe operation of aircraft from public access areas.

(e) When additional security is deemed required, a cleared area shall be provided on both sides of the fence or barrier to make patrolling easier and trespassing more challenging. Consideration shall be given to providing maintenance employees and security patrols with a perimeter road within the barrier of the aerodrome.

191.325 Security lighting

At aerodromes where it is considered appropriate for security purposes, a fence or other barrier erected to protect international civil aviation and its facilities shall be lit to a minimum essential level. Consideration shall be given to the placement of lights to illuminate the ground on both sides of the fence or barrier, especially at access points.

191.327 Surface movement guidance and control systems

(a) A surface movement guidance and control system (SMGCS) shall be provided at an aerodrome.

(b) The design of an SMGCS shall take into account:

(1) the density of air traffic;

(2) the visibility conditions under which operations are intended;

(3) the need for pilot orientation;

(4) the complexity of the aerodrome layout; and

(5) movements of vehicles.

(c) The visual aid components of an SMGCS, such as markings, lights, and signs, shall be designed to meet the relevant specifications in Subarts J,K and L respectively.

(d) An SMGCS shall be designed to aid in the prevention of unintentional aircraft and vehicle incursions onto an active runway.

(e) The system shall be designed to help prevent collisions between aircraft, as well as collisions between aircraft and vehicles or objects, on any part of the movement area.

(f) The following requirements shall be met when an SMGCS is provided by selective switching of stop bars and taxiway centre line lights:

(1) taxiway routes indicated by illuminated taxiway centre line lights shall be capable of being terminated by an illuminated stop bar;

(2) control circuits shall be configured in such a way that when a stop bar located ahead of an aircraft is illuminated, the appropriate section of taxiway centre line lights beyond it is suppressed; and

(3) taxiway centre line lights are activated when the stop bar is suppressed.

Note 1: For specifications on taxiway centre line lights and stop bars, see OTAR 191.219 and OTAR 191.225, respectively.

Note 2: The Aerodrome Design Manual (Doc 9157), Part 4 contains guidance on installation of stop bars and taxiway centre line lights in SMGCSs.

Appendix A – Colours for aeronautical ground lights, markings, signs and panels

The following requirements outline the chromaticity restrictions for aeronautical ground lights, markers, signs, and panels. The requirements comply with the International Commission on Illumination (CIE) specifications from 1983, except for the orange colour in Figure APP.A-3.

For practically certain recognition, it is crucial that the eye illumination is substantially above the threshold of perception, that the colour is not significantly altered by selected ambient attenuations, and that the observer has adequate colour vision. There is also a risk of colour confusion at an exceptionally high degree of eye light, such as that produced by a source of high intensity at close range. Developing colour criteria that exclude the chance of confusion is impossible. Experience indicates that appropriate recognition can be attained if these criteria are carefully considered.

The chromaticities are expressed using the standard observer and coordinate system developed by the International Commission on Illumination (CIE) during its Eighth Session in 1931 in Cambridge, England.

Except for the blue boundary of white, the chromaticity of solid-state lighting (e.g., LED) is based on the standard S 004/E-2001 for chromaticity of the International Commission of Illumination (CIE) .

Colours for aeronautical ground lights

191.APP-A.1 Chromaticity specifications for lights having filament-type light sources

(a) The chromaticity specifications for aeronautical ground lights using filament-type light sources are as follows:

CIE Equations (see Figure APP-A.1):

(i) Red:

Purple boundary	y = 0.980 – x
Yellow boundary	y = 0.335, except for visual approach slope indicator systems
Yellow boundary	y = 0.320, for visual approach slope indicator systems

Note: See OTAR 191.219 and OTAR 191.197 (t).

(ii) Yellow:

Red boundary	y = 0.382
White boundary	y = 0.790 – 0.667x
Green boundary	y = x – 0.120

(iii) Green:

Yellow boundary	x = 0.360 – 0.080y
White boundary	x = 0.650y
Blue boundary	y = 0.390 – 0.171x

(iv) Blue:

Green boundary	y = 0.805x + 0.065
White boundary	y = 0.400 – x
Purple boundary	x = 0.600y + 0.133

(v) White:

Yellow boundary	x = 0.500
Blue boundary	x = 0.285
Green boundary	y = 0.440 and y = 0.150 + 0.640x
Purple boundary	y = 0.050 + 0.750x and y = 0.382

(vi) Variable white

Yellow boundary	x = 0.255 + 0.750y and y = 0.790 – 0.667x
Blue boundary	x = 0.285
Green boundary	y = 0.440 and y = 0.150 + 0.640x
Purple boundary	y = 0.050 + 0.750x and y = 0.382

Note: Part 4 of the Aerodrome Design Manual (Doc 9157) provides guidance on chromaticity changes caused by the effect of temperature on filtering components.

(b) Where dimming is not required, or observers with impaired colour vision shall be able to distinguish the colour of the light, green signals shall fall within the following parameters:

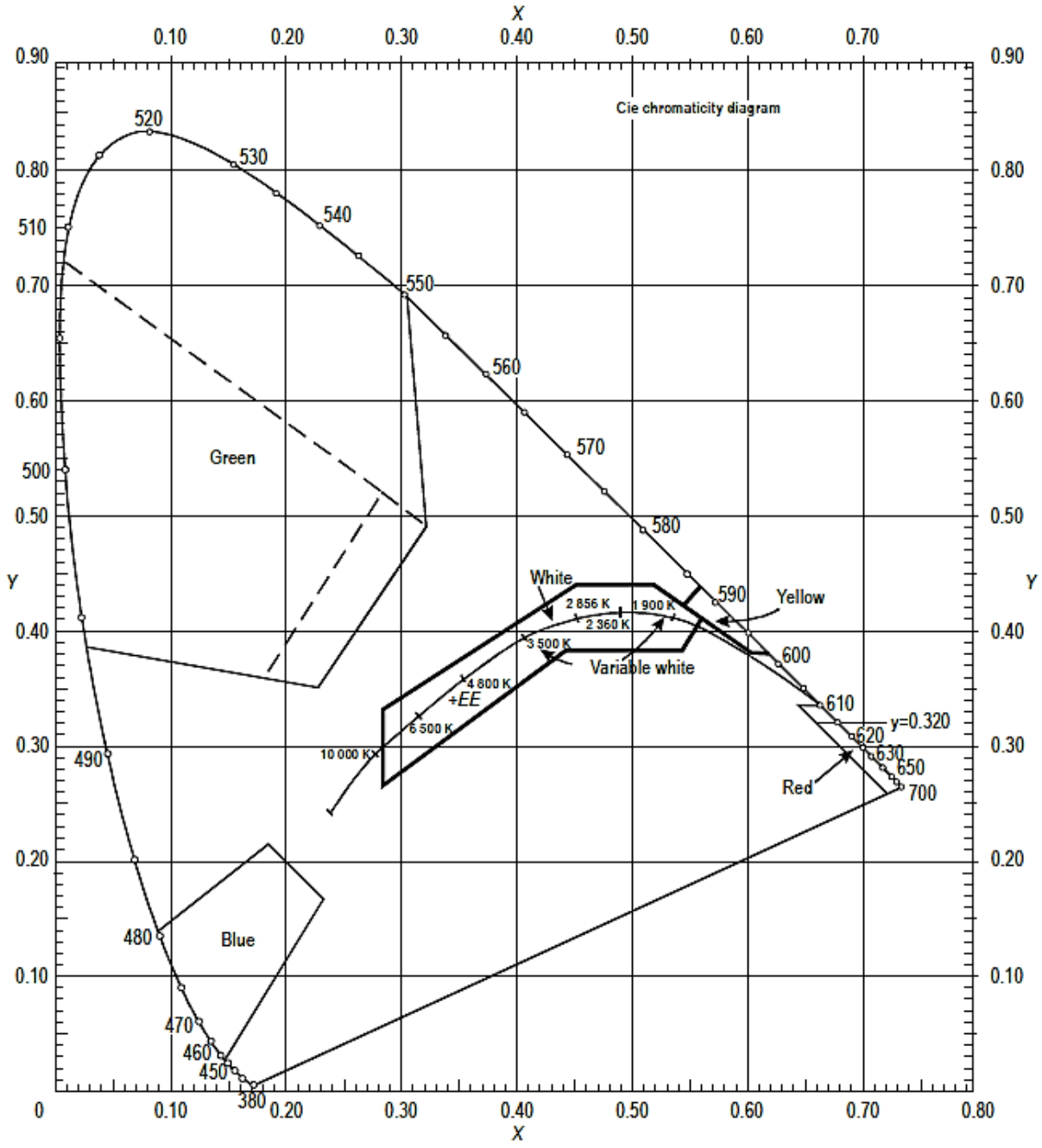
Yellow boundary	y = 0.726 – 0.726x
White boundary	x = 0.650y
Blue boundary	y = 0.390 – 0.171x

Note: When the colour signal is to be viewed from a great distance, it has been customary to employ colours within the parameters of OTAR 191.APP-A.1 (b).

(c) Where increased certainty of white recognition is more important than maximum visual range, green signals shall adhere to the following parameters:

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

Figure APP-A.1: Colours for aeronautical ground lights (filament-type lamps)



Source: ICAO Annex 14 Volume 1

191.APP-A.2 Discrimination between lights having filament-type sources

(a) If yellow and white shall be distinguished, they shall be displayed in close proximity in time or space, such as by being flashed successively from the same beacon.

(b) If it is necessary to distinguish yellow from green and/or white, such as on exit taxiway centre line lights, the y coordinates of the yellow light shall not exceed 0.40.

Note: The white limits have been established based on the assumption that they will be used in situations where the characteristics of the light source (colour temperature) will remain relatively constant.

(c) Variable white is intended only for lights whose intensity shall be varied, such as to prevent dazzling. If white is to be distinguished from yellow, the lights shall be designed and operated such that:

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

(2) the yellow lights are displayed simultaneously and close to the white lights.

191.APP-A.3 Chromaticity specifications for lights having a solid-state light source

(a) The chromaticities of aeronautical ground lights using solid state light sources, such as LEDs, shall fall between these limits:

CIE Equations (see Figure APP-A.2):

(i) Red

Purple boundary	y = 0.980 – x
Yellow boundary	y = 0.335, except for visual approach slope indicator systems
Yellow boundary	y = 0.320, for visual approach slope indicator systems

Note: See OTAR 191.219 and OTAR 191.197 (t).

(ii) Yellow

Red boundary	y = 0.387
White boundary	y = 0.980 – x
Green boundary	y = 0.727x + 0.054

(iii) Green (also refer to 191.APP-A3 (b) and (c))

Yellow boundary x = 0.310

White boundary x = 0.625y – 0.041

Blue boundary y = 0.400

(iv) Blue

Green boundary y = 1.141x – 0.037

White boundary y = 0.400 – y

Purple boundary x = 0.134 + 0.590y

(v) White

Yellow boundary x = 0.440

Blue boundary x = 0.320

Green boundary y = 0.150 + 0.643x

Purple boundary y = 0.050 + 0.757x

(vi) Variable white

The boundaries of variable white for solid state light sources are those of OTAR 191.APP-3 (a) (v) White above.

(b) Green signals shall be within the following boundaries where observers with poor colour vision shall be able to determine the colour of the light:

Yellow boundary y = 0.726 – 0.726x

White boundary x = 0.625y – 0.041

Blue boundary y = 0.400

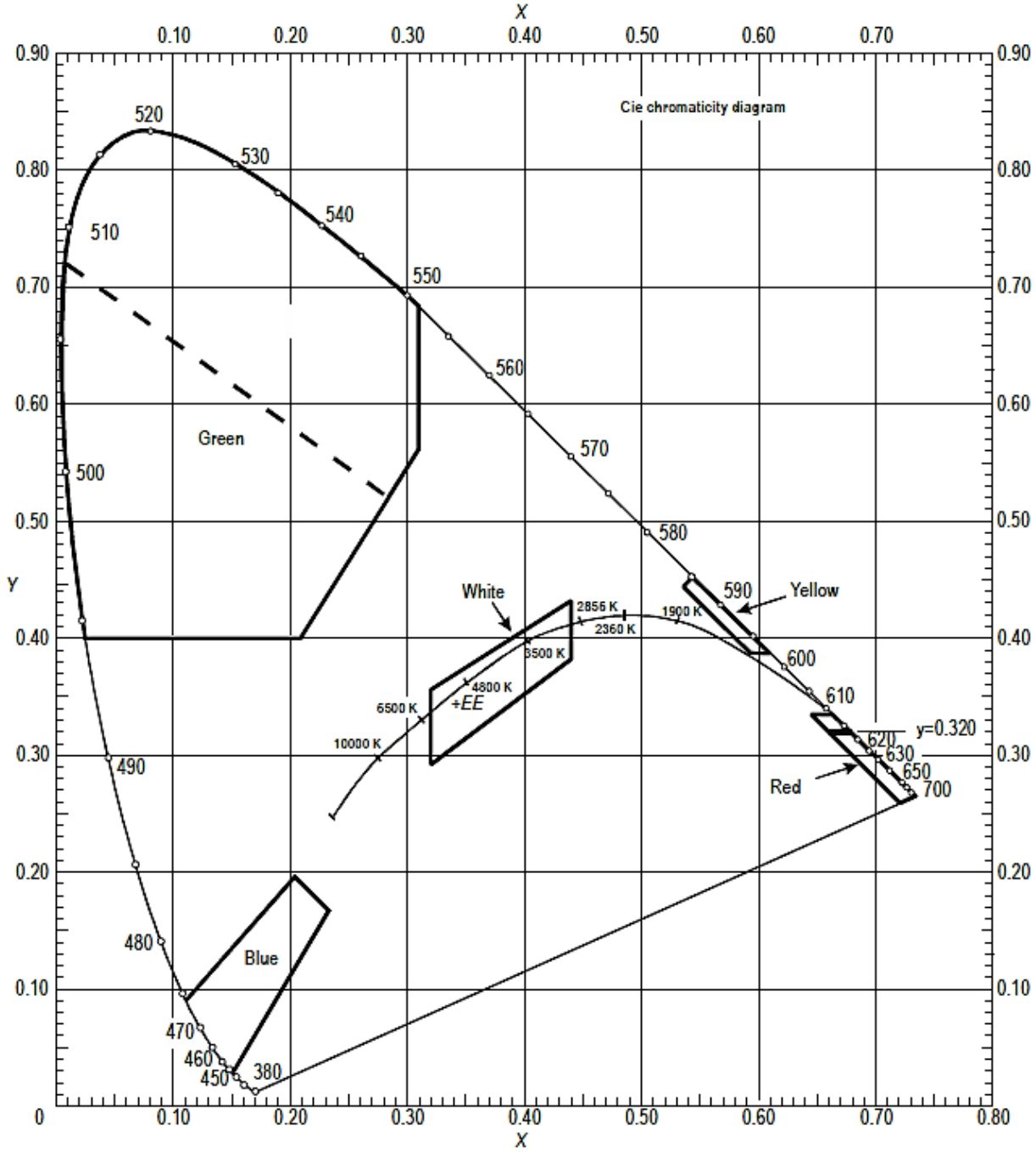
(c) If colours within the boundaries below are chosen, colours within the boundaries of OTAR 191.APP-3 (b) shall not be used to avoid a wide range of green shades.

Yellow boundary x = 0.310

White boundary x = 0.625y – 0.041

Blue boundary y = 0.726 – 0.726x

Figure APP-A.2: Colours for aeronautical ground lights (solid state lighting)



Source: ICAO Annex 14 Volume 1

191.APP-A.4 Colour measurement for filament-type and solid state-type light sources

(a) The colour of aeronautical ground lights shall be verified as being within the boundaries specified in Figure APP-A.1 or APP-A.2, as applicable, by measuring at five points within the area limited by the innermost isocandela curve (isocandela diagrams in Appendix B refer), while operating at rated current or voltage. Colour measurements shall be taken at the centre and the horizontal and vertical limits of elliptical or circular isocandela curves. The colour measurements for rectangular isocandela curves shall be taken at the centre and the diagonal limits (corners). Furthermore, the colour of the light shall be checked at the outermost isocandela curve to ensure that no colour shift could cause signal confusion to the pilot.

Note 1: For the outermost isocandela curve, colour coordinates should be measured and recorded for review and acceptance by the Goveror.

Note 2: Certain light units may be designed to be viewed and used by pilots from directions other than the outermost isocandela curve (e.g. stop bar lights at significantly wide runway-holding positions). In such cases, the Governor will evaluate the actual application and, if necessary, require a colour shift check at angular ranges beyond the outermost curve.

(b) Colour shall be measured at points in accordance with OTAR 191.APP-A.4 (a) in the case of visual approach slope indicator systems and other light units with a colour transition sector, except that the colour areas shall be treated separately, and no point shall be within 0.5 degrees of the transition sector.

Colours for markings, signs and panels

191.APP-A.5 General information

The surface colour specifications listed below apply only to freshly coloured surfaces. Colours used for markings, signs, and panels typically fade over time and shall be replaced.

The CIE document Recommendations for Surface Colors for Visual Signaling — Publication No. 39-2 (TC-106) 1983 contains surface colour guidance.

The recommendations in OTAR 191.APP-A.5 (d) for transilluminated panels are provisional and are based on the CIE specifications for transilluminated signs. These specifications are intended to be reviewed and updated as CIE develops specifications for transilluminated panels.

(a) The chromaticities and luminance factors of standard colours, retroreflective colours, and transilluminated (internally illuminated) signs and panels shall be determined under the following standard conditions:

(i) illumination angle: 45°,

(ii) viewing direction: perpendicular to the surface; and

(iii) illuminant: CIE standard illuminant D65.

(b) When measured under standard conditions, standard colours' chromaticity and luminance factors for markings and externally illuminated signs and panels shall fall within the following limits.

CIE Equations (see Figure APP-A.3):

(i) 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 (mnm)

(ii) 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 (mnm)

(iii) 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 (mnm)

(iv) 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 (mnm)

(v) 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 (max)

(vi) Yellowish green

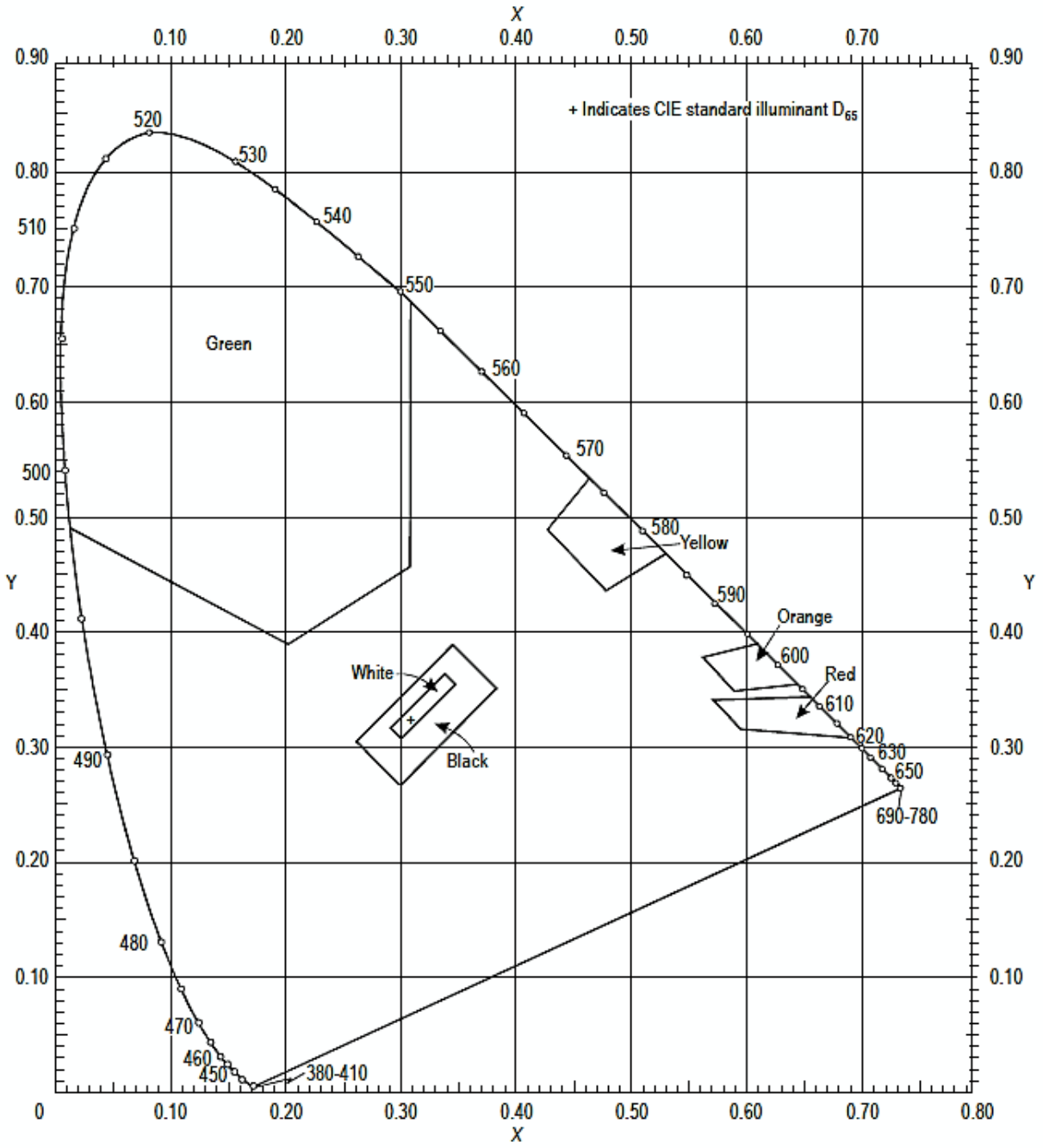
Green boundary	y = 1.317x + 0.4
White boundary	y = 0.910 – x
Yellow boundary	y = 0.867x + 0.4

(vii) 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 (mnm)

Note: The small separation between surface red and surface orange is insufficient to distinguish these colours when viewed separately.

Figure APP-A.3: Ordinary colours for markings and externally illuminated signs and panels



Source: ICAO Annex 14 Volume 1

(c) When determined under standard conditions, the chromaticity and luminance factors of colours of retroreflective materials for markings, signs, and panels shall fall within the following limits.

CIE Equations (see Figure APP-A.4):

(i) 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 (mnm)

(ii) 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 (mnm)

(iii) 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 (mnm)

(iv) 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 (mnm)

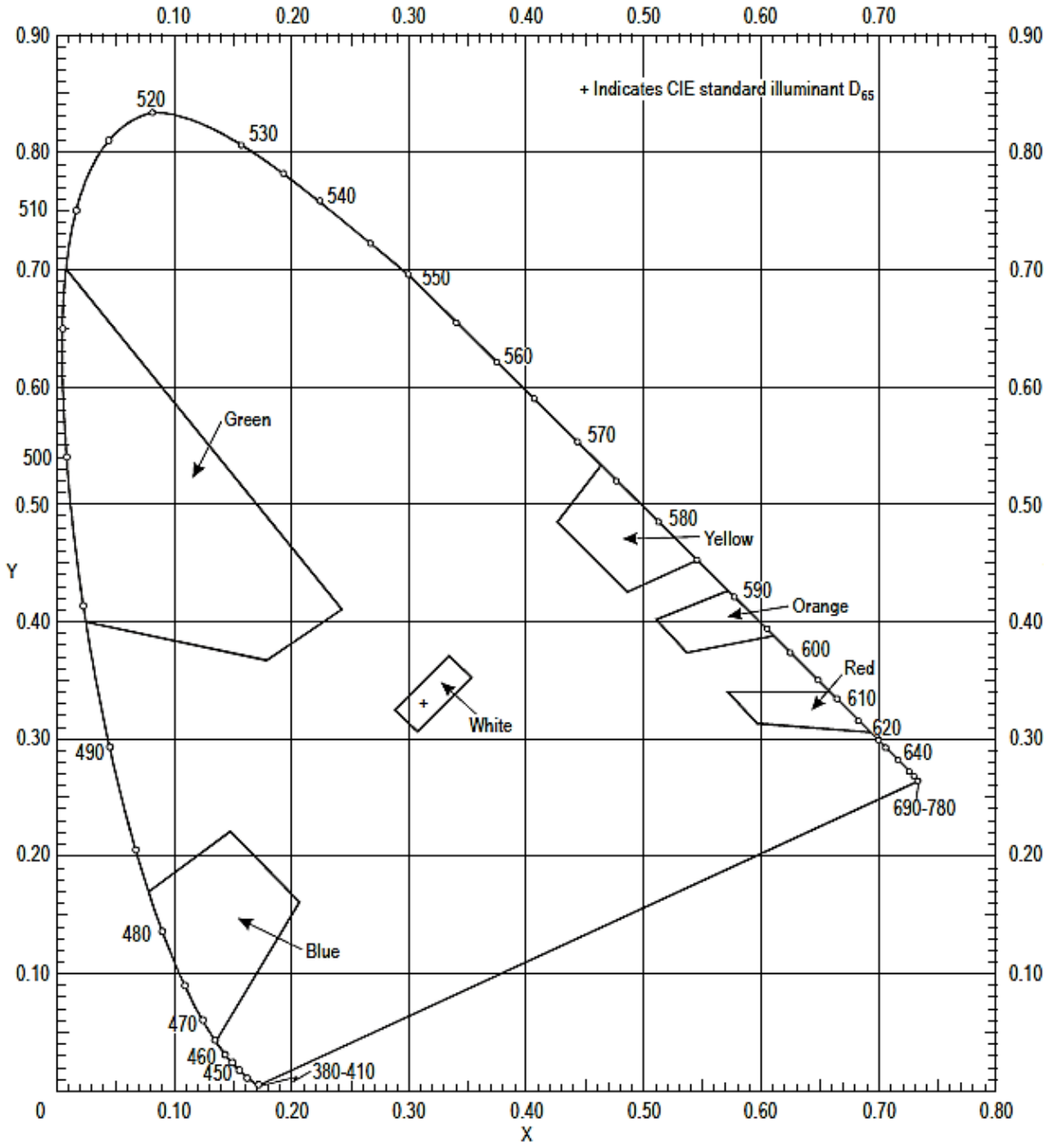
(v) Blue

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 (mnm)

(vi) 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 (mnm)

Figure APP-A.4: Colours of retroreflective materials for markings, signs and panels



Source: ICAO Annex 14 Volume 1

(d) When measured under standard conditions, the chromaticity and luminance factors of colours for luminescent or transilluminated (internally illuminated) signs and panels shall fall within the following limits.

CIE Equations (see Figure APP-A.5):

(i) 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 (mnm)
Relative luminance to white (night condition)	5% (mnm) 20% (max)

(ii) 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 (mnm)
Relative luminance to white (night condition)	30% (mnm) 80% (max)

(iii) 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 (mnm)
Relative luminance to white (night condition)	100%

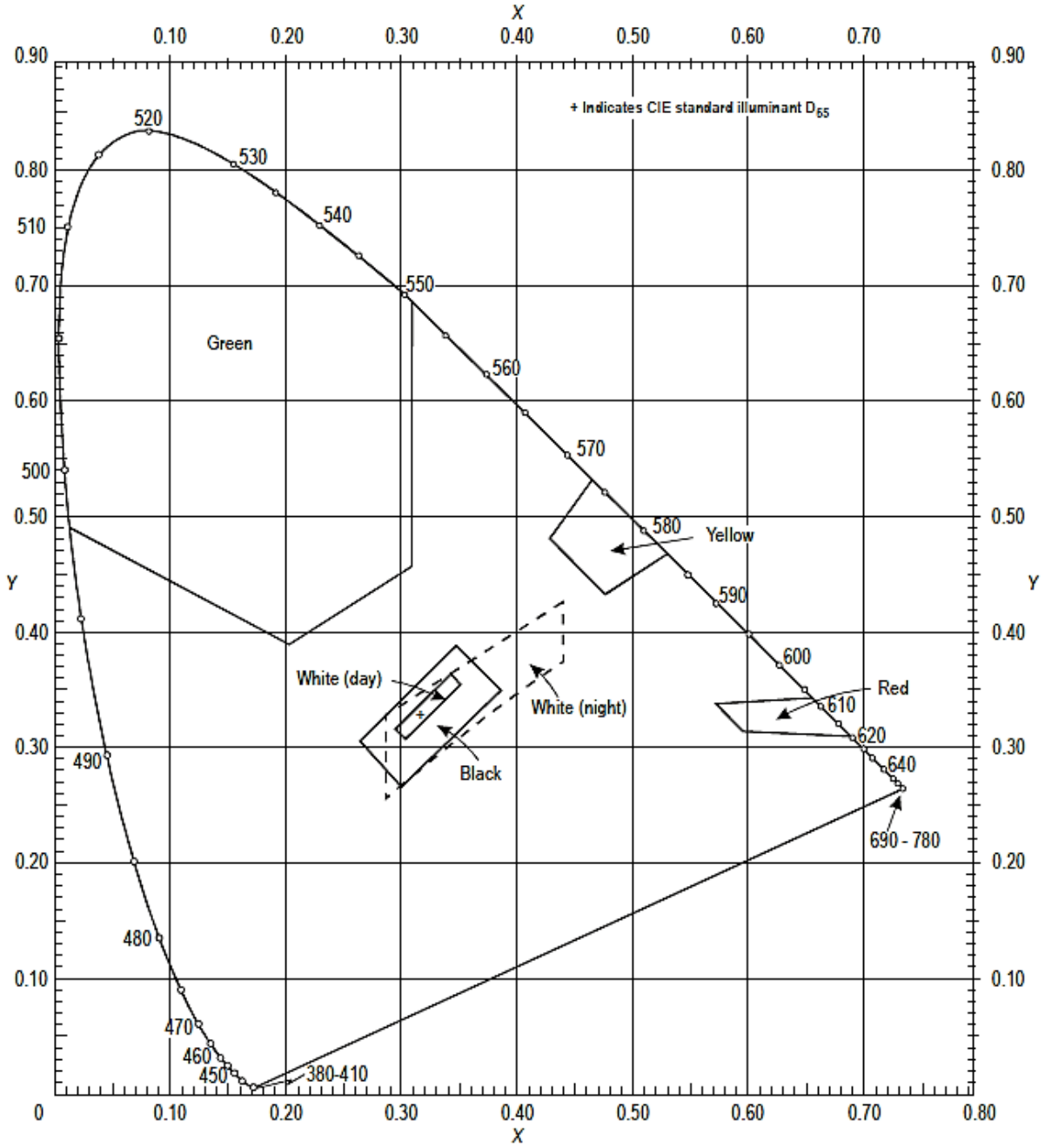
(iv) Black

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 (max)
Relative luminance to white (night condition)	0% (mnm) 2% (max)

(v) 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 (day conditions)
Relative luminance to white (night conditions)	5% (minimum) 30% (maximum)

Figure APP-A.5: Colours of luminescent or transilluminated (internally illuminated) signs and panels

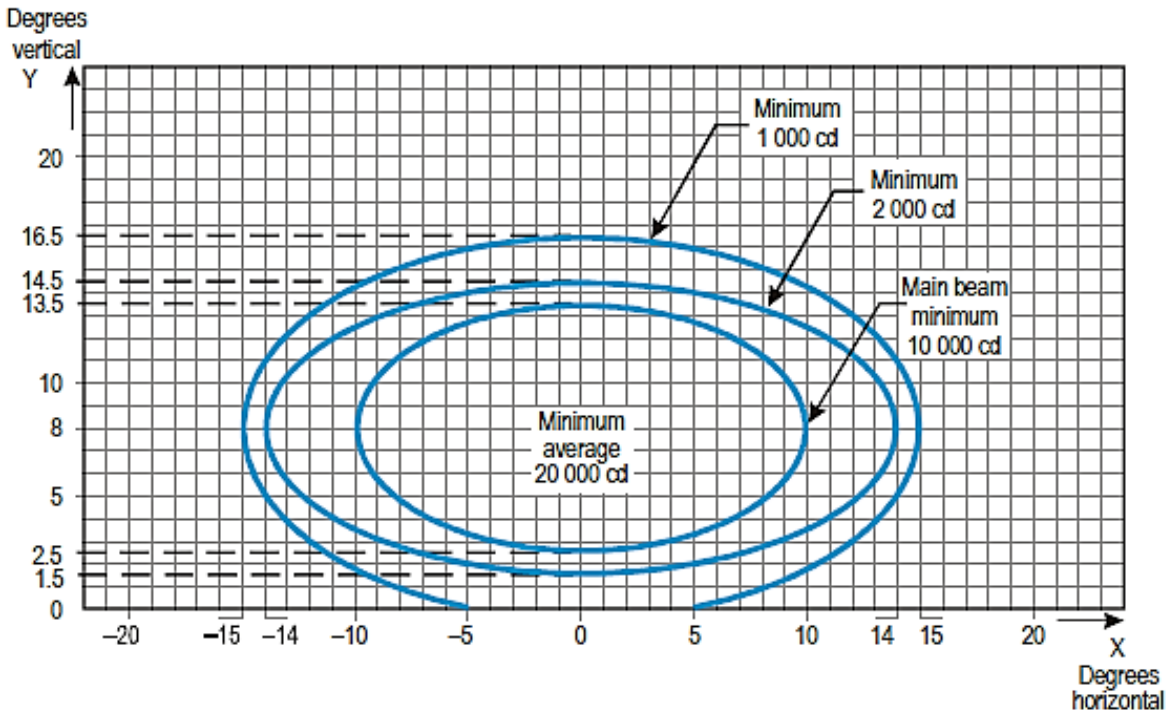


Source: ICAO Annex 14 Volume 1

Appendix B – Aeronautical ground light characteristics

191.APP-B.1 Approach centre line light and crossbars (white light)

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



Source: ICAO Annex 14 Volume 1

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

a	10	14	15
b	5.5	6.5	8.5

(b) The vertical setting angles of the lights shall be such that the vertical coverage of the main beam is as follows:

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

(c) Lights in crossbars located more than 22.5 metres from the centre line shall be toed in 2 degrees. All other lights shall be parallel to the runway centre line.

(d) The ellipses of each figure are symmetrical about the common vertical and horizontal axes.

(e) The minimum allowable light intensities are shown in Figure APP-B.1. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(f) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(g) According to Figure APP-B.1 (Approach centre line and crossbars), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 1.5 to 2.0 (white light).

(h) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(i) Horizontal angles are measured with respect to the vertical plane along the runway centre line. The direction towards the runway centre line is considered positive for other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

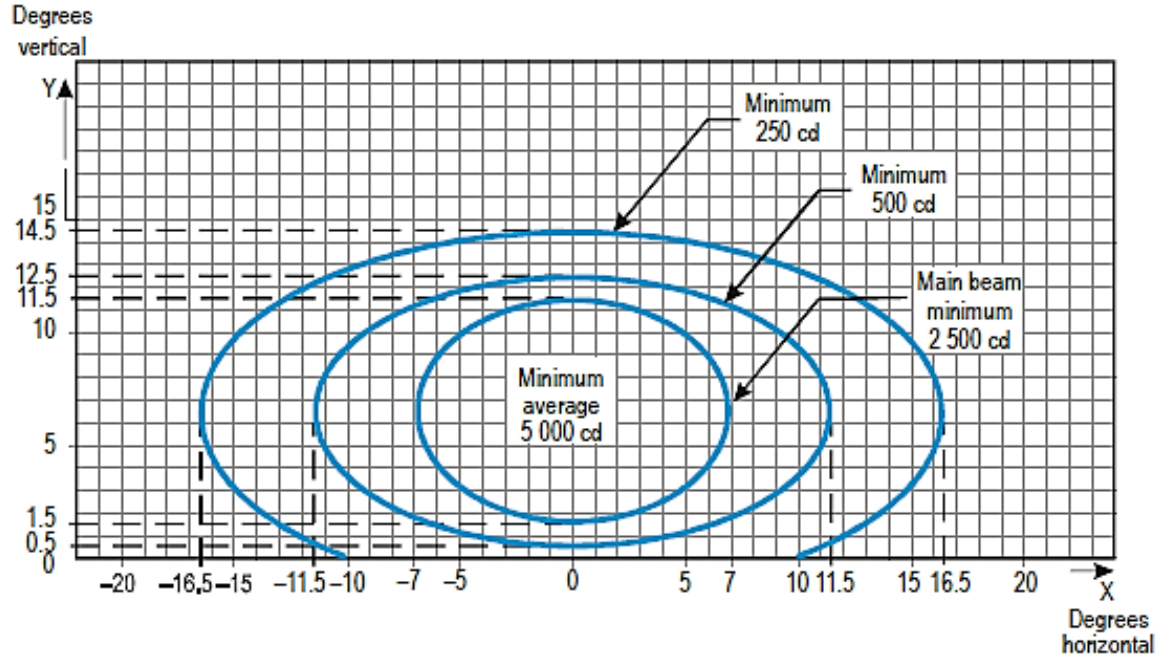
(j) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(k) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(l) The light unit shall be installed so that the main beam is aligned within a one-half degree of the specified requirement.

191.APP-B.2 Approach side row light (red light)

Figure APP-B.2: Isocandela diagram for approach side row light (red light)



Source: ICAO Annex 14 Volume 1

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

a	7.0	11.5	16.5
b	5.0	6.0	8.0

(2) Toe-in 2 degrees

(3) Vertical setting angles of the lights shall be such that the following vertical coverage of the main beam will be met:

distance from threshold	vertical main beam coverage
the threshold to 115 m	0.5° — 10.5°
116 m to 215 m	1° — 11°
216 m and beyond	1.5° — 11.5° (as illustrated above)

(4) The ellipses of each figureare symmetrical about the common vertical and horizontal axes.

(5) The minimum allowable light intensities are shown in Figure APP-B.2. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(6) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(7) According to Figure APP-B.2 (Approach side row), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 0.5 to 1.0 (red light).

(8) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(9) Horizontal angles are measured with respect to the vertical plane along the runway centre line. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

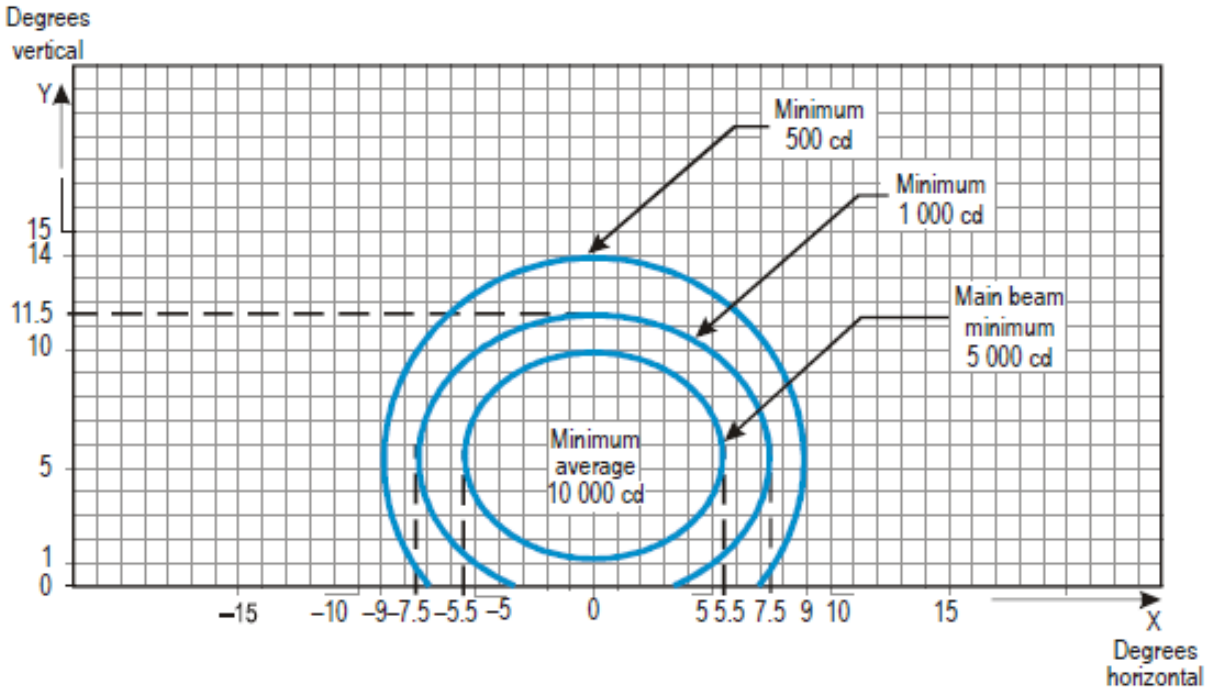
(10) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(11) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(12) The light unit shall be installed so that the main beam is aligned to within a one-half degree of the specified requirement.

191.APP-B.3 Threshold light (green light)

Figure APP-B.3 Isocandela diagram for threshold light (green light)



Source: ICAO Annex 14 Volume 1

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

a	5.5	7.5	9.0
b	4.5	6.0	8.5

(b) Toe-in 3.5 degrees

(c) The ellipses of each figureare symmetrical about the common vertical and horizontal axes.

(d) The minimum allowable light intensities are shown in Figure APP-B.3. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(e) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(f) According to Figure APP-B.3 (Threshold), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 1.0 to 1.5 (green light).

(g) The beam coverages depicted in the ficture provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(h) Horizontal angles are measured with respect to the vertical plane along the runway centre line. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

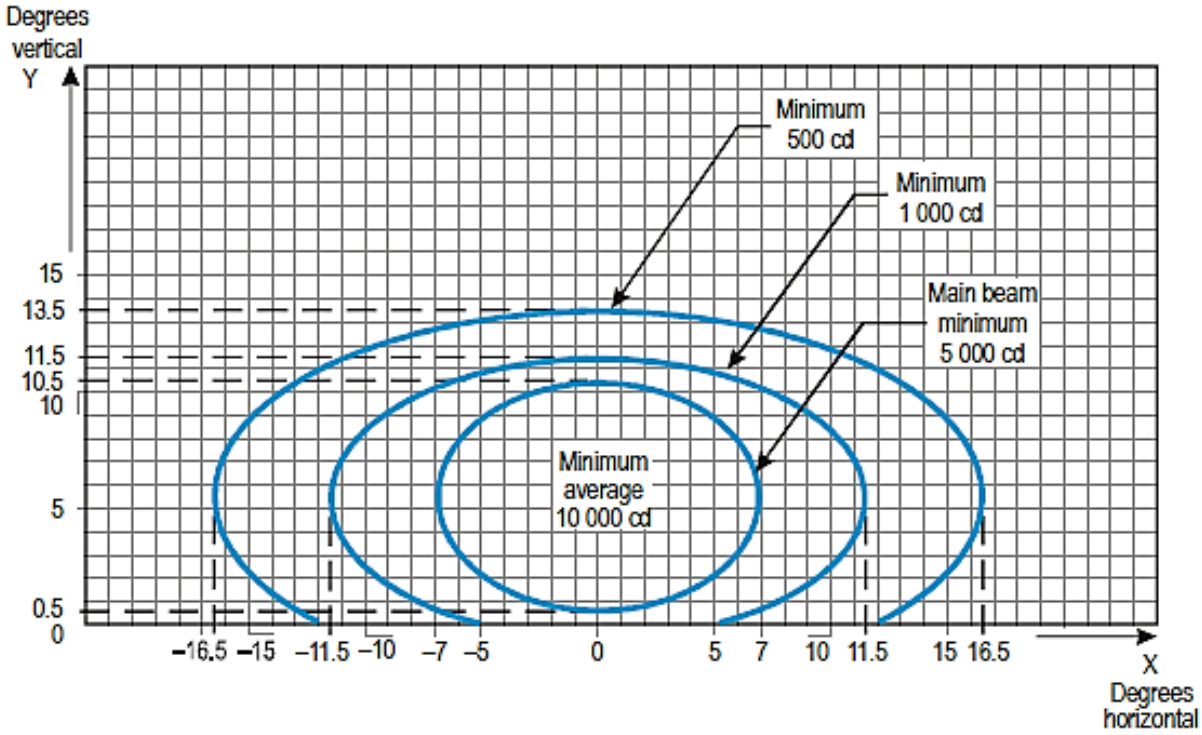
(i) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(j) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(k) The light unit shall be installed so that the main beam is aligned to within a one-half degree of the specified requirement.

191.APP-B.4 Threshold wing bar light (green light)

Figure APP-B.4: Isocandela diagram for threshold wing bar light (green light)



Source: ICAO Annex 14 Volume 1

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

a	7.0	11.5	16.5
b	5.0	6.0	8.0

(2) Toe-in 2 degrees

(3) The ellipses of each figureellipses are symmetrical about the common vertical and horizontal axes.

(4) The minimum allowable light intensities are shown in Figure APP-B.4. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(5) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(6) According to Figure APP-B.4 (Threshold wing bar), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 1.0 to 1.5 (green light).

(7) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(8) Horizontal angles are measured with respect to the vertical plane along the runway centre line. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

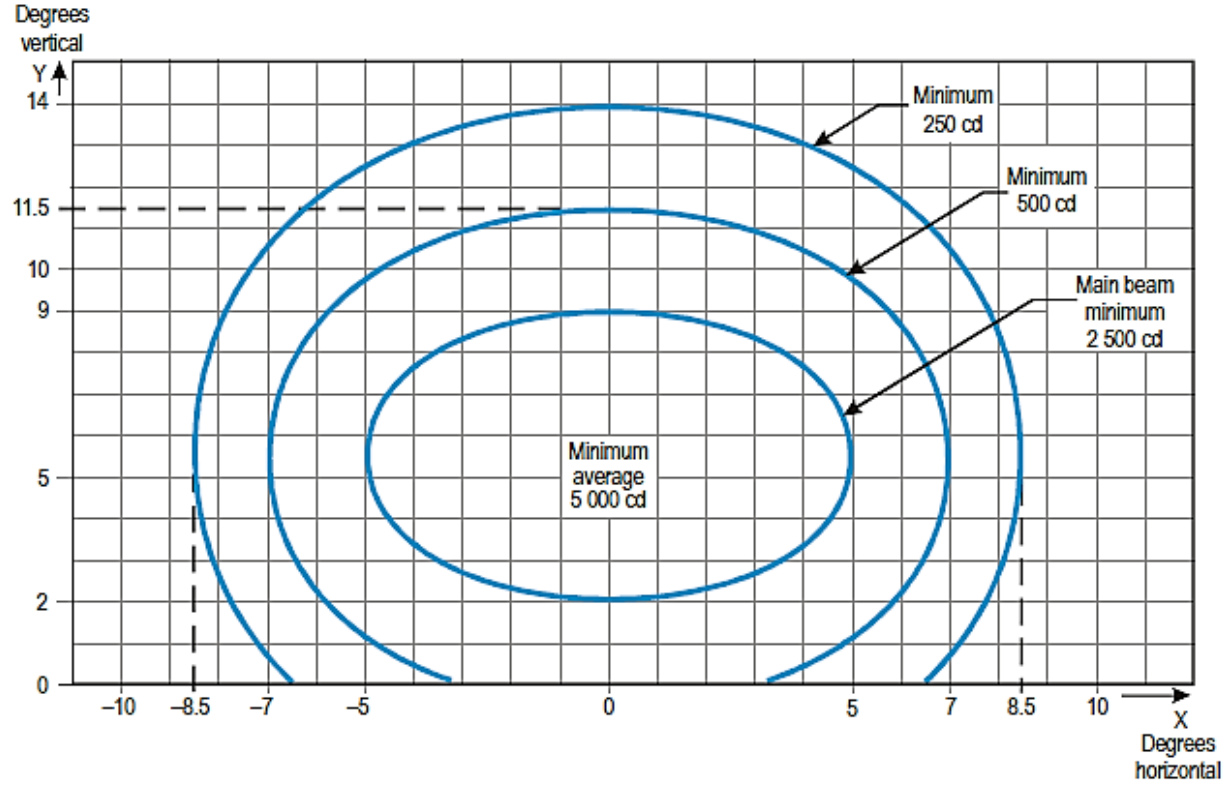
(9) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(10) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(11) The light unit shall be installed so that the main beam is aligned to within a one-half degree of the specified requirement.

191.APP-B.5 Touchdown zone light (white light)

Figure APP-B.5: Isocandela diagram for touchdown zone light (white light)



Source: ICAO Annex 14 Volume 1

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

a	5.0	7.0	8.5
b	3.5	6.0	8.5

(2) Toe-in 4 degrees

(3) The ellipses of each figureellipses are symmetrical about the common vertical and horizontal axes.

(4) The minimum allowable light intensities are shown in Figure APP-B.5. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(5) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(6) According to Figure APP-B.5 (Touchdown zone), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 0.5 to 1.0 (white light).

(7) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(8) Horizontal angles are measured with respect to the vertical plane along the runway centre line. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

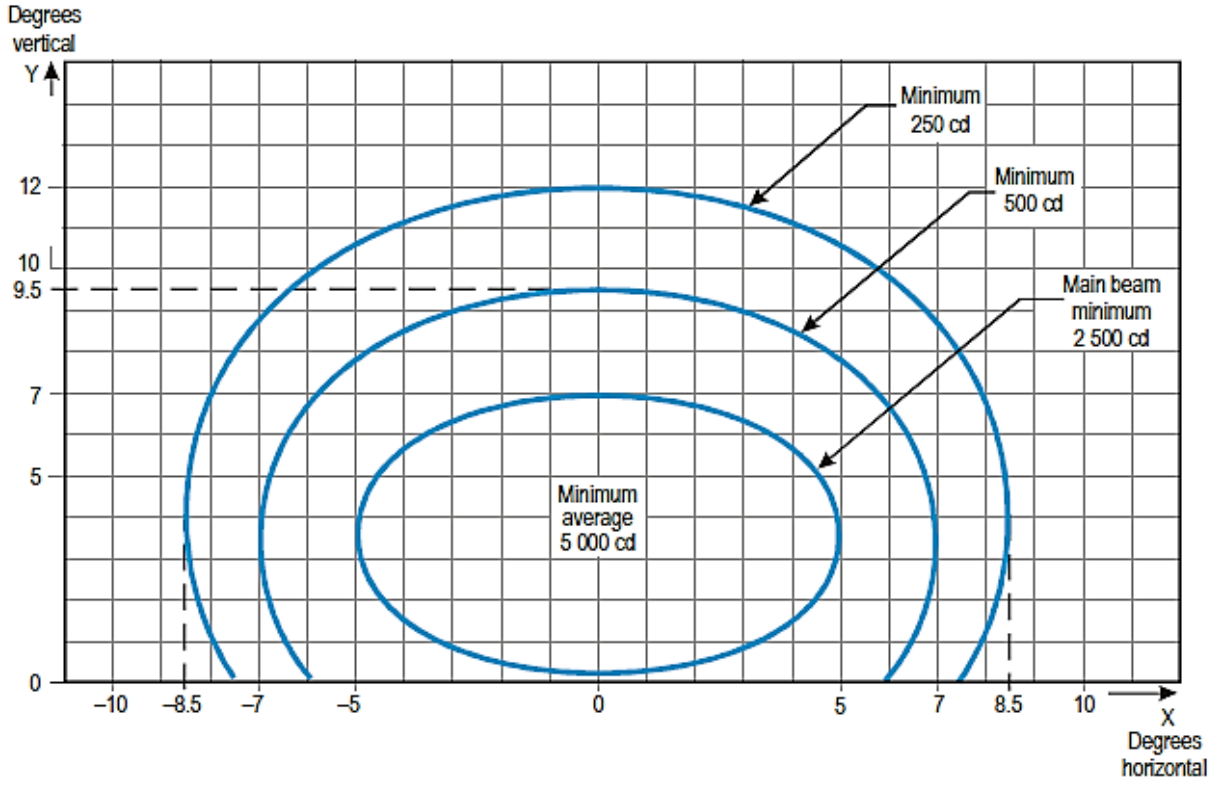
(9) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(10) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(11) The light unit shall be installed in such a way that the main beam is aligned to within a one-half degree of the specified requirement.

191.APP-B.6 Runway centre line light with 30 m longitudinal spacing (white light) and rapid exit taxiway indicator light (yellow light)

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



Source: ICAO Annex 14 Volume 1

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

a	5.0	7.0	8.5
b	3.5	6.0	8.5

(2) For red light, multiply values by 0.15.

(3) For yellow light, multiply values by 0.40.

(4) The ellipses of each figureare symmetrical about the common vertical and horizontal axes.

(5) The minimum allowable light intensities are shown in Figure APP-B.6. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(6) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(7) According to Figure APP-B.6 (Runway centre line (longitudinal spacing 30 m)), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 0.5 to 1.0 (white light).

(8) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(9) Horizontal angles are measured concerning the vertical plane along the centre line of the runway. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

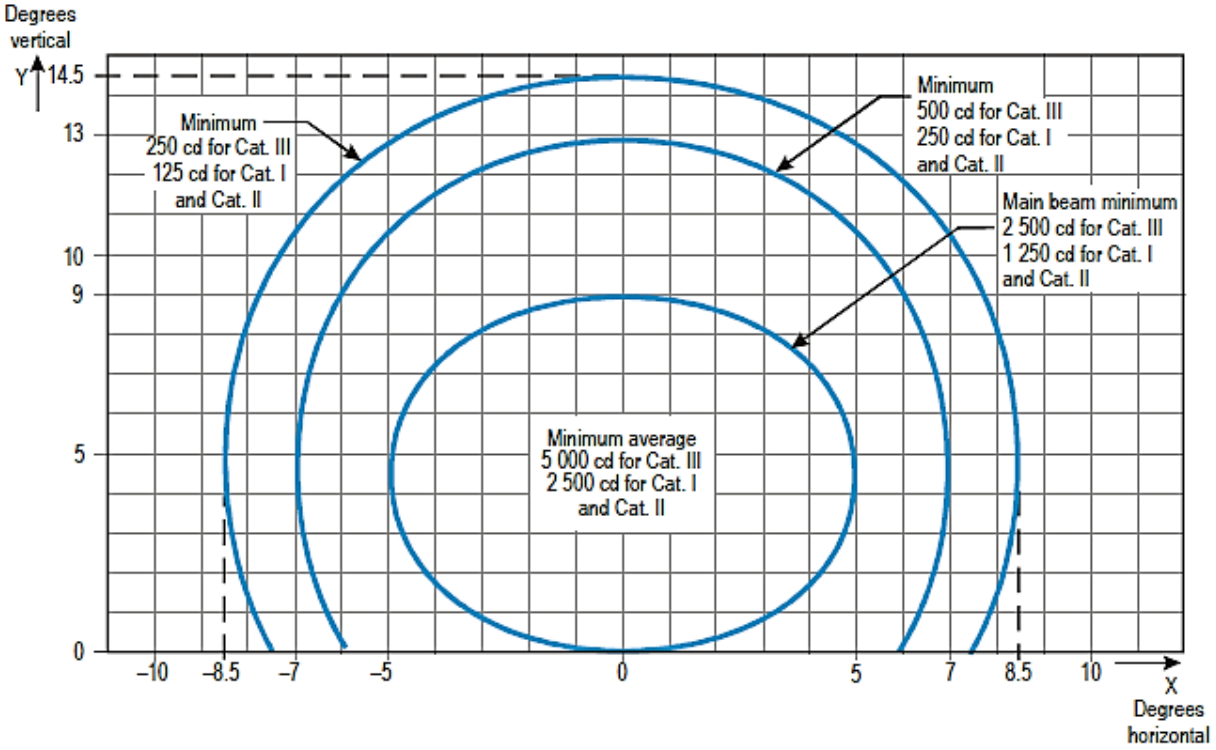
(10) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(11) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(12) The light unit shall be installed so that the main beam is aligned to within a one-half degree of the specified requirement.

191.APP-B.7 Runway centre line light with 15 m longitudinal spacing (white light) and rapid exit taxiway indicator light (yellow light)

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



Source: ICAO Annex 14 Volume 1

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

a	5.0	7.0	8.5
b	4.5	8.5	10

(b) For red light, multiply values by 0.15.

(c) For yellow light, multiply values by 0.40.

(d) The ellipses of each figureare symmetrical about the common vertical and horizontal axes.

(e) The minimum allowable light intensities are shown in Figure APP-B.7. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(f) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(g) According to Figure APP-B.7 (Runway centre line (longitudinal spacing 15 m)), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 0.5 to 1.0 for CAT III (white light) and 0.25 to 0.5 for CAT I, II (white light).

(h) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(i) Horizontal angles are measured concerning the vertical plane along the centre line of the runway. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

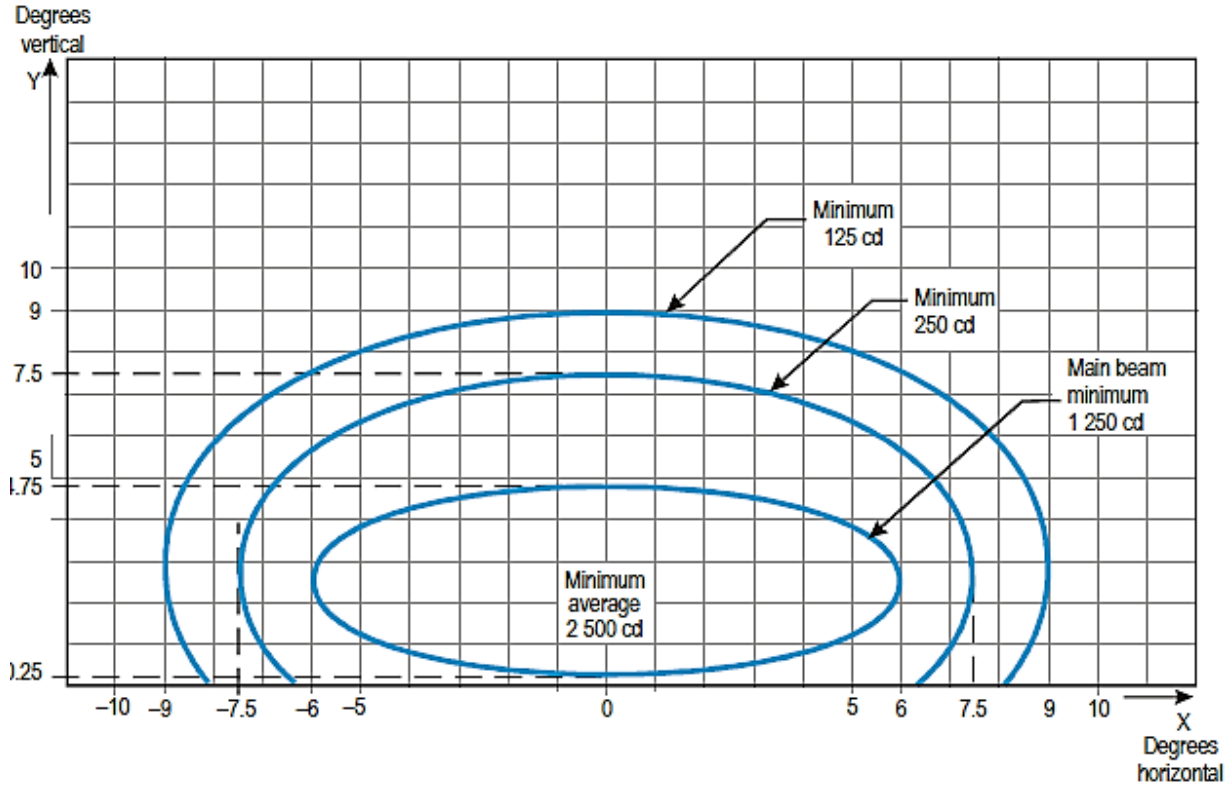
(j) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(k) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(l) The light unit shall be installed so that the main beam is aligned to within a one-half degree of the specified requirement.

191.APP-B.8 Runway end light (red light)

Figure APP-B.8: Isocandela diagram for runway end light (red light)



Source: ICAO Annex 14 Volume 1

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

a	6.0	7.5	9.0
b	2.25	5.0	6.5

(2) The ellipses of each figureare symmetrical about the common vertical and horizontal axes.

(3) The minimum allowable light intensities are shown in Figure APP-B.8. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(4) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(5) According to Figure APP-B.8 (Runway end), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 0.25 to 0.5 (red light).

(6) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(7) Horizontal angles are measured concerning the vertical plane along the centre line of the runway. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

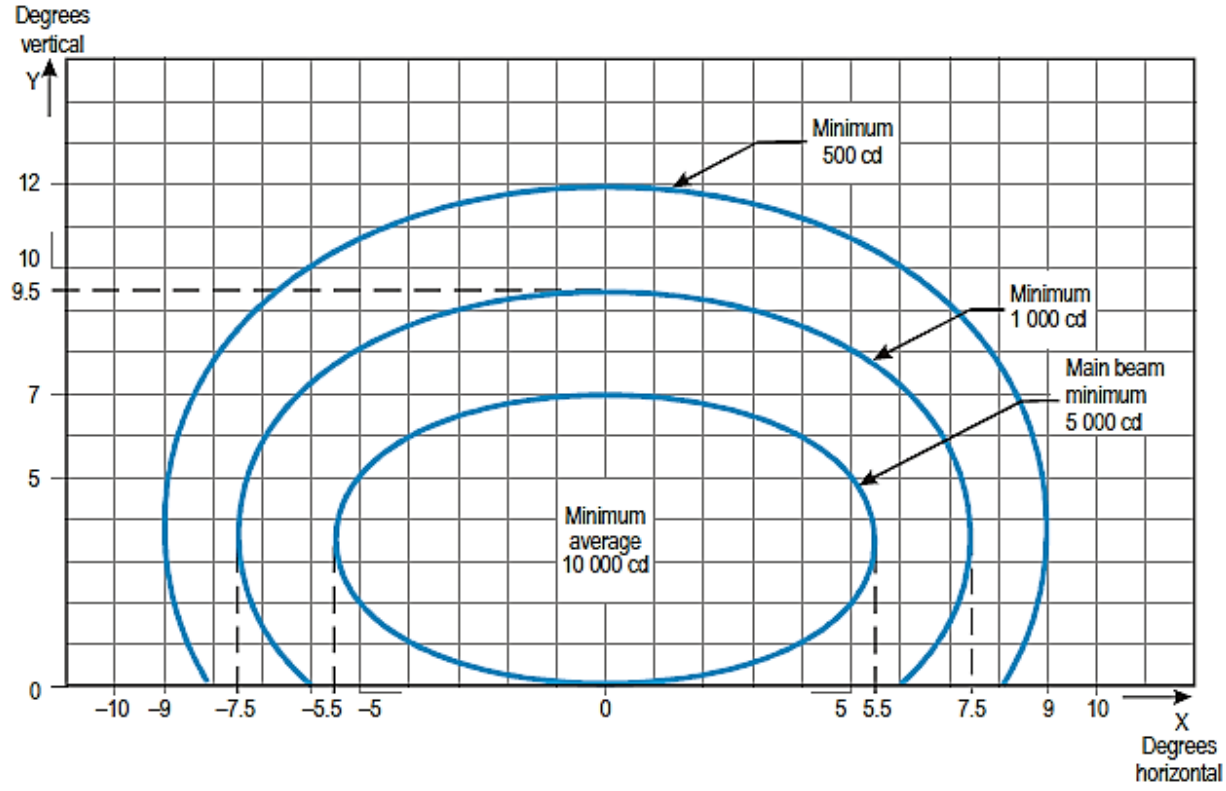
(8) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(9) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(10) The light unit shall be installed so that the main beam is aligned to within a one-half degree of the specified requirement.

191.APP-B.9 Runway edge light where the width of the runway is 45 m (white light)

Figure APP-B.9: Isocandela diagram for runway edge light where the width of the runway is 45 m (white light)



Source: ICAO Annex 14 Volume 1

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

a	5.5	7.5	9.0
b	3.5	6.0	8.5

(2) Toe-in 3.5 degrees

(3) For red light, multiply values by 0.15.

(4) For yellow light, multiply values by 0.40.

(5) The ellipses of each figureare symmetrical about the common vertical and horizontal axes.

(6) The minimum allowable light intensities are shown in Figure APP-B.9. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(7) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(8) According to Figure APP-B.9 (Runway edge (45 m runway width)), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 1.0 (white light).

(9) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(10) Horizontal angles are measured concerning the vertical plane along the centre line of the runway. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

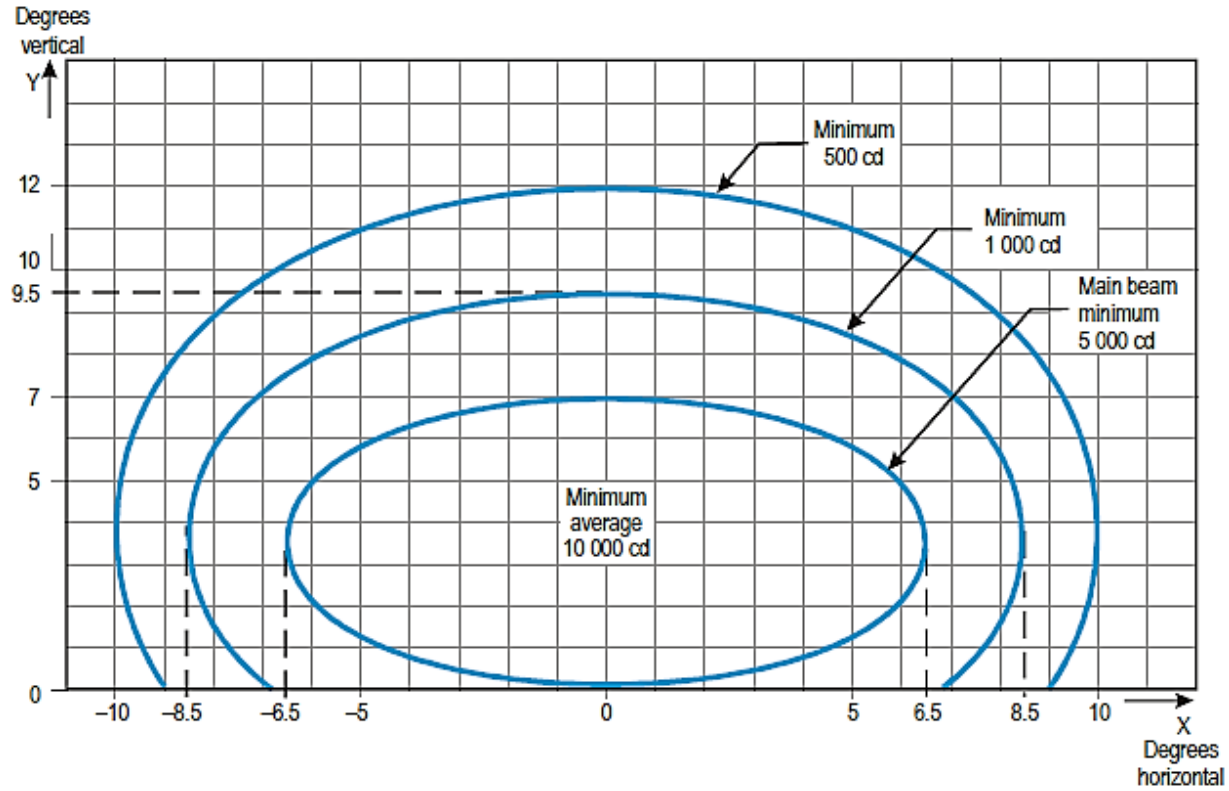
(11) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(12) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(13) The light unit shall be installed so that the main beam is aligned to within a one-half degree of the specified requirement.

191.APP-B.10 Runway edge light where the width of the runway is 60 m (white light)

Figure APP-B.10: Isocandela diagram for runway edge light where the width of the runway is 60 m (white light)



Source: ICAO Annex 14 Volume 1

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

a	6.5	8.5	10.0
b	3.5	6.0	8.5

(2) Toe-in 4.5 degrees

(3) For red light, multiply values by 0.15.

(4) For yellow light, multiply values by 0.40.

(5) The ellipses of each figureare symmetrical about the common vertical and horizontal axes.

(6) The minimum allowable light intensities are shown in figure APP-B.10. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(7) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(8) According to Figure APP-B.10 (Runway edge (60 m runway width)), the ratio between the ellipse defining the main beam of a typical new light and the average light intensity of the main beam of a new runway edge light shall be 1.0 (white light).

(9) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

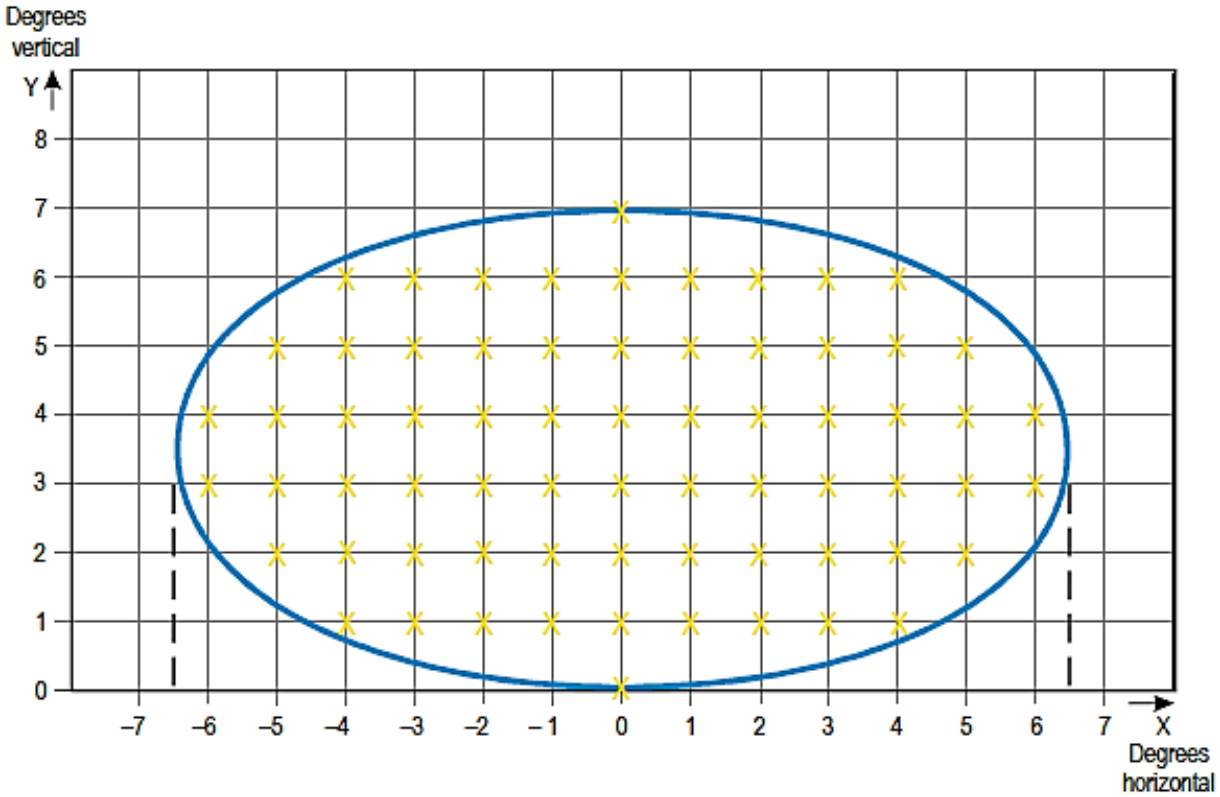
(10) Horizontal angles are measured concerning the vertical plane along the centre line of the runway. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

(11) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(12) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(13) The light unit shall be installed so that the main beam is aligned to within a one-half degree of the specified requirement.

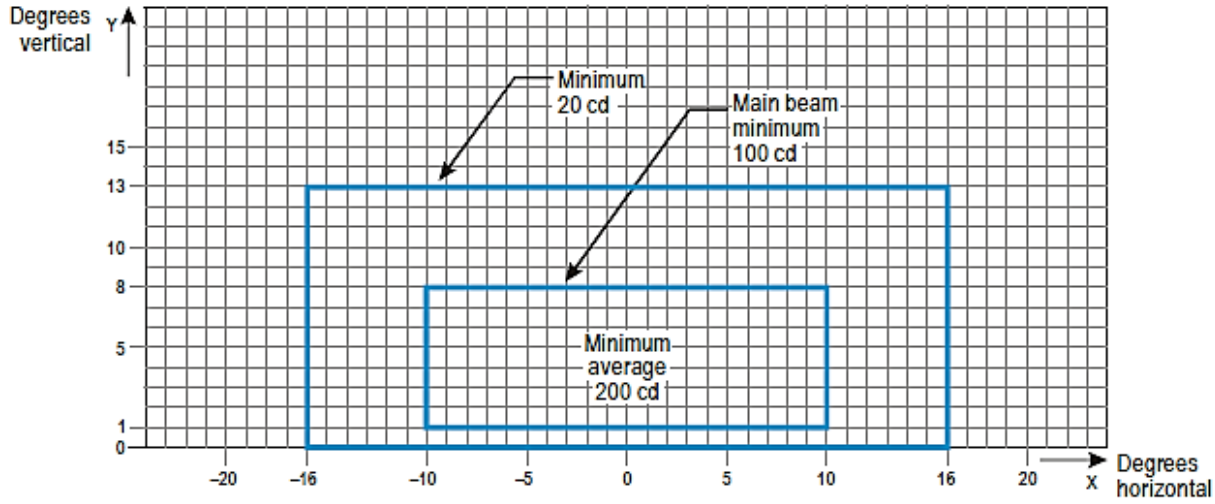
Figure APP-B.11: Grid points to calculate the average intensity of approach and runway lights.



Source: ICAO Annex 14 Volume 1

191.APP-B.11 Taxiway centre line (15 m spacing), RELs, no-entry bar, and stop bar lights in straight sections intended for use in RVR of less than a value of 350 m where large offsets can occur and for low-intensity runway guard lights, Configuration B

Figure APP.B-12: Isocandela diagram for taxiway centre line (15 m spacing), RELs, no-entry bar, and stop bar lights in straight sections intended for use in RVR of less than a value of 350 m where large offsets can occur and for low-intensity runway guard lights, Configuration B



Source: ICAO Annex 14 Volume 1

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

(b) Figure APP.B-12 shows the intensities in green and yellow lights for taxiway centre line lights, yellow for runway guard lights, and red for stop bar lights.

(c) The minimum allowable light intensities are shown in Figure APP.B-12. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP.B-21 and using the intensity values measured at all grid points located within and on the perimeter of the main beam rectangle. The average value is the arithmetic mean of the light intensities measured at all considered grid points.

(d) When the lighting fixture is aimed correctly, no deviations in the main beam or the innermost beam are acceptable.

(e) Except for curves, horizontal angles are measured concerning the vertical plane through the taxiway centre line

(f) Vertical angles are measured from the longitudinal slope of the taxiway surface.

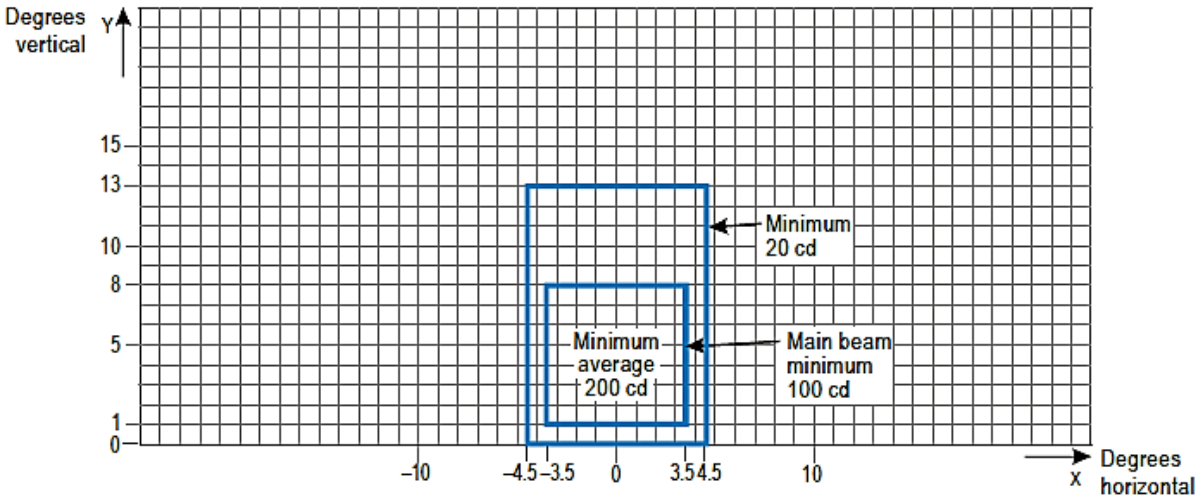
(g) The significance of proper maintenance cannot be overstated. The intensity, either average where applicable or as specified on the corresponding isocandela curves, shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to keep light output close to the specified minimum average intensity.

(h) The light unit shall be installed so that the main or innermost beam, as applicable, is aligned within a one-half degree of the specified requirement.

(i) Increased intensities for increased rapid exit taxiway centre line lights are four times the respective intensities in the figure (i.e., 800 cd for minimum average main beam), as specified in OTAR 191.223 (k)).

191.APP-B.12 Taxiway centre line (15 m spacing), no-entry bar, and stop bar lights in straight sections intended for use in RVR of less than a value of 350 m

Figure APP.B-13: Isocandela diagram for taxiway centre line (15 m spacing), no-entry bar, and stop bar lights in straight sections intended for use in RVR of less than a value of 350 m



Source: ICAO Annex 14 Volume 1

(a) These beam coverages are generally sufficient and accommodate a standard cockpit displacement of around 3 metres from the centre line.

(b) Figure APP.B-13 shows the intensities in green and yellow lights for taxiway centre line lights, yellow for runway guard lights, and red for stop bar lights.

(c) The minimum allowable light intensities are shown in Figure APP.B-12. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP.B-21 and using the intensity values measured at all grid points located within and on the perimeter of the main beam rectangle. The average value is the arithmetic mean of the light intensities measured at all considered grid points.

(d) When the lighting fixture is aimed correctly, no deviations in the main beam or the innermost beam are acceptable.

(e) Except for curves, horizontal angles are measured concerning the vertical plane through the taxiway centre line

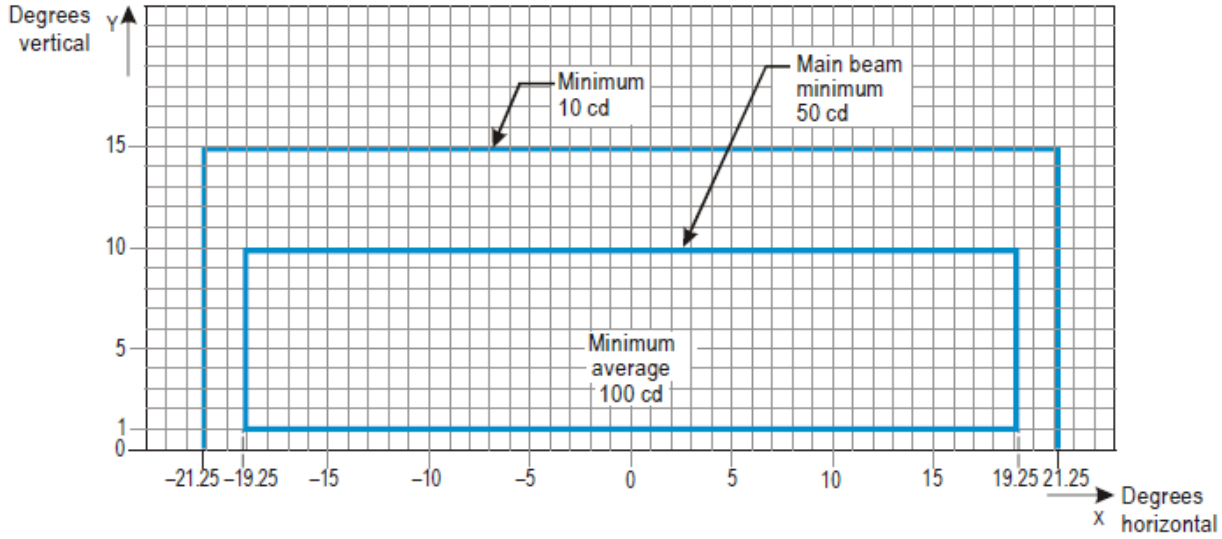
(f) Vertical angles are measured from the longitudinal slope of the taxiway surface.

(g) The significance of proper maintenance cannot be overstated. The intensity, either average where applicable or as specified on the corresponding isocandela curves, shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to keep light output close to the specified minimum average intensity.

(h) The light unit shall be installed so that the main or innermost beam, as applicable, is aligned within a one-half degree of the specified requirement.

191.APP-B.13 Taxiway centre line (7.5 m spacing), RELs, no-entry bar, and stop bar lights in curved sections intended for use in RVR of less than a value of 350 m

Figure APP.B-14: Isocandela diagram for taxiway centre line (7.5 m spacing), RELs, no-entry bar, and stop bar lights in curved sections intended for use in RVR of less than a value of 350 m



Source: ICAO Annex 14 Volume 1

(a) Lights on curves shall be toed at 15.75 degrees relative to the tangent of the curve. The exception is runway entry lights (RELs).

(b) Increased intensities for RELs shall be double the prescribed intensities, i.e., minimum 20 cd, minimum 100 cd for the main beam, and minimum 200 cd for the average.

(c) Figure APP.B-14 shows the intensities in green and yellow lights for taxiway centre line lights, yellow for runway guard lights, and red for stop bar lights.

(d) The minimum allowable light intensities are shown in Figure APP.B-12. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP.B-21 and using the intensity values measured at all grid points located within and on the perimeter of the main beam rectangle. The average value is the arithmetic mean of the light intensities measured at all considered grid points.

(e) When the lighting fixture is aimed correctly, no deviations in the main beam or the innermost beam are acceptable.

(f) Except for curves, horizontal angles are measured concerning the vertical plane through the taxiway centre line

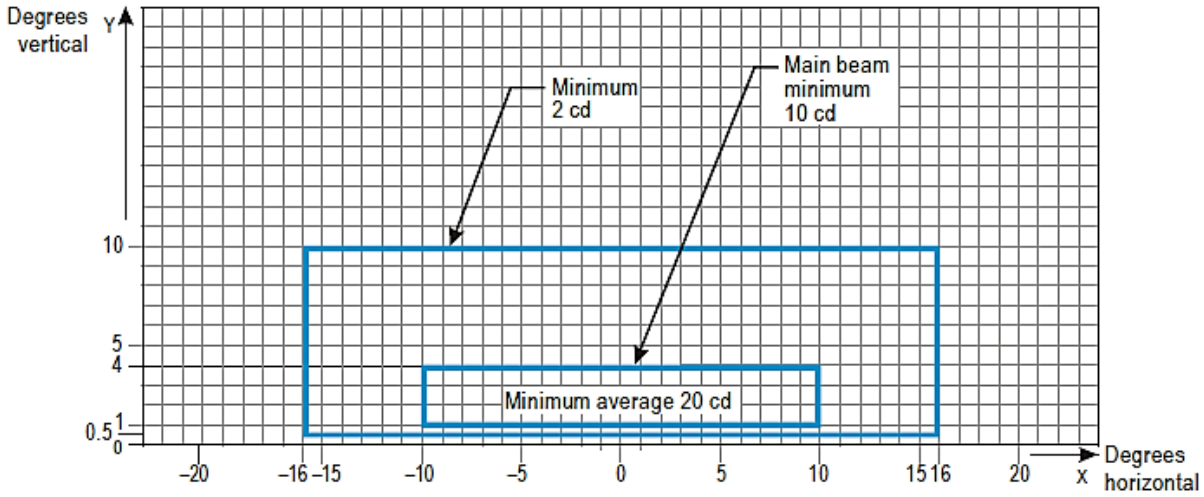
(g) Vertical angles are measured from the longitudinal slope of the taxiway.

(h) The significance of proper maintenance cannot be overstated. The intensity, either average where applicable or as specified on the corresponding isocandela curves, shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to keep light output close to the specified minimum average intensity.

(i) The light unit shall be installed so that the main or innermost beam, as applicable, is aligned within a one-half degree of the specified requirement.

191.APP-B.14 Taxiway centre line (30 m, 60 m spacing), no-entry bar, and stop bar lights in straight sections intended for use in RVR of 350 m or greater

Figure APP.B-15: Isocandela diagram for taxiway centre line (30 m, 60 m spacing), no-entry bar and stop bar lights in straight sections intended for use in RVR of 350 m or greater



Source: ICAO Annex 14 Volume 1

(a) The cd-values shall be multiplied by 2.5 in areas where high background luminance is typical and where degradation of light output due to dust, snow, and local contamination is a significant factor.

(b) Omnidirectional lights shall adhere to the vertical beam requirements shown in this diagram.

(c) Figure APP.B-15 shows the intensities in green and yellow lights for taxiway centre line lights, yellow for runway guard lights, and red for stop bar lights.

(d) The minimum allowable light intensities are shown in Figure APP.B-12. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP.B-21 and using the intensity values measured at all grid points located within and on the perimeter of the main beam rectangle. The average value is the arithmetic mean of the light intensities measured at all considered grid points.

(e) When the lighting fixture is aimed correctly, no deviations in the main beam or the innermost beam are acceptable.

(f) Except for curves, horizontal angles are measured concerning the vertical plane through the taxiway centre line

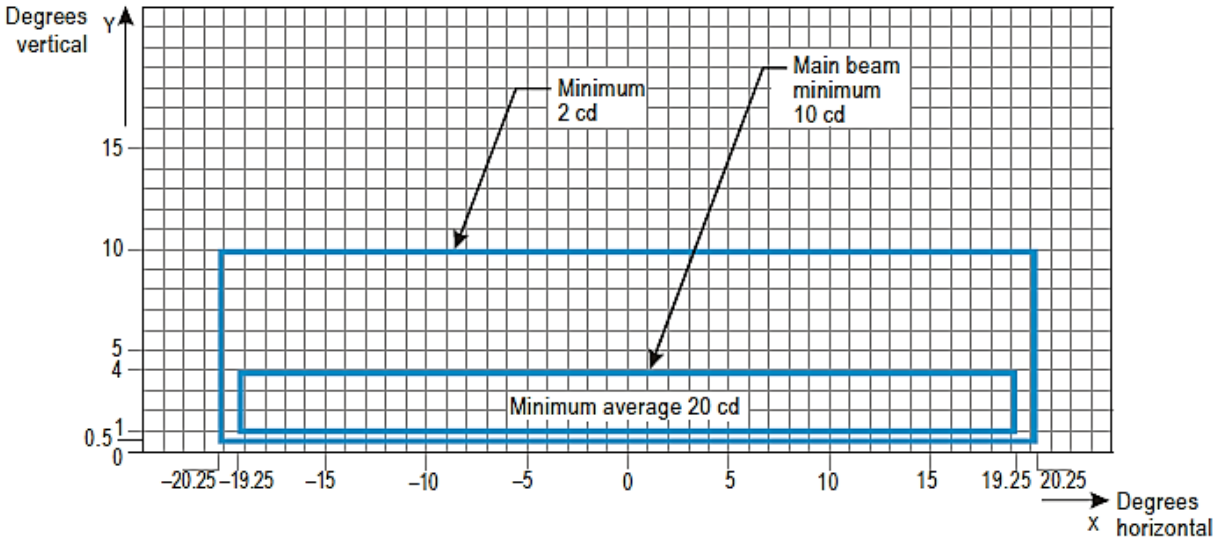
(g) Vertical angles are measured from the longitudinal slope of the taxiway.

(h) The significance of proper maintenance cannot be overstated. The intensity, either average where applicable or as specified on the corresponding isocandela curves, shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to keep light output close to the specified minimum average intensity.

(i) The light unit shall be installed so that the main or innermost beam, as applicable, is aligned within a one-half degree of the specified requirement.

191.APP-B.15 Isocandela diagram for taxiway centre line (7.5 m, 15 m, 30 m spacing), no-entry bar and stop bar lights in curved sections intended for use in RVR of 350 m or greater

Figure APP-B.16: Isocandela diagram for taxiway centre line (7.5 m, 15 m, 30 m spacing), no-entry bar and stop bar lights in curved sections intended for use in RVR of 350 m or greater



Source: ICAO Annex 14 Volume 1

(a) Lights on curves shall be toed at 15.75 degrees relative to the tangent of the curve.

(b) The cd-values shall be multiplied by 2.5 in areas where high background luminance is typical and where degradation of light output due to dust, snow, and local contamination is a significant factor.

(c) These beam coverages allow up to 12 m of cockpit displacement from the centreline after a curve.

(d) Figure APP.B-16 shows the intensities in green and yellow lights for taxiway centre line lights, yellow for runway guard lights, and red for stop bar lights.

(e) The minimum allowable light intensities are shown in Figure APP.B-12. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP.B-21 and using the intensity values measured at all grid points located within and on the perimeter of the main beam rectangle. The average value is the arithmetic mean of the light intensities measured at all considered grid points.

(f) When the lighting fixture is aimed correctly, no deviations in the main beam or the innermost beam are acceptable.

(g) Except for curves, horizontal angles are measured concerning the vertical plane through the taxiway centre line

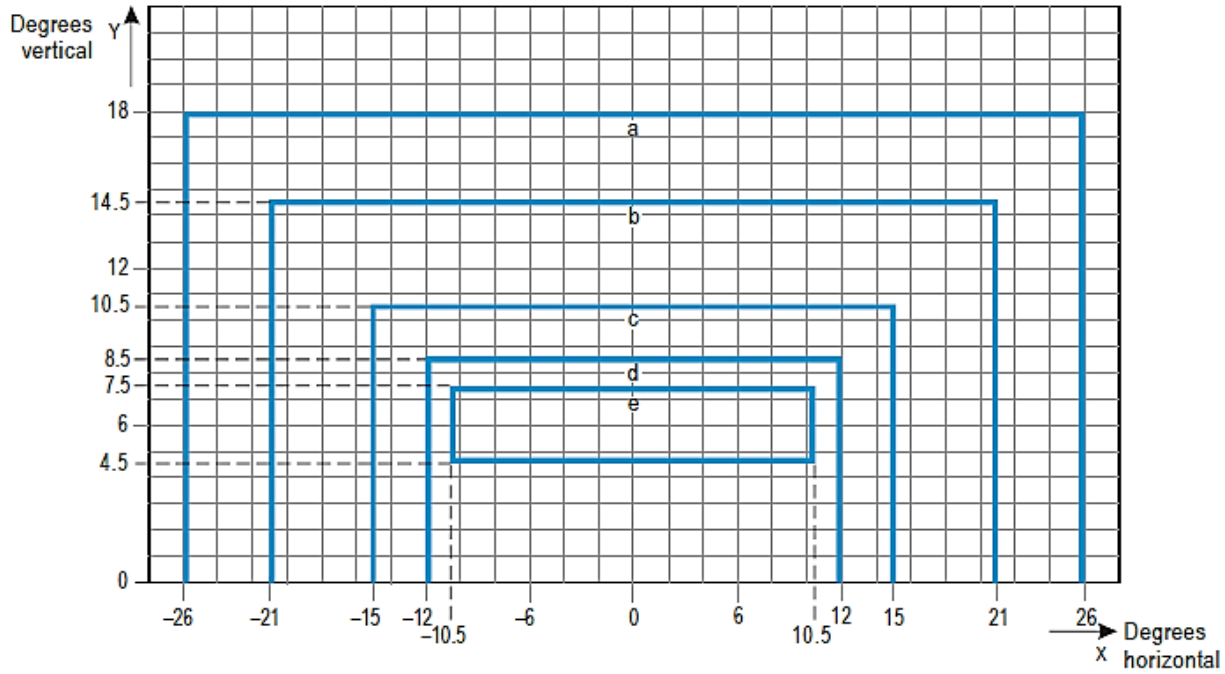
(h) Vertical angles are measured from the longitudinal slope of the taxiway.

(i) The significance of proper maintenance cannot be overstated. The intensity, either average where applicable or as specified on the corresponding isocandela curves, shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to keep light output close to the specified minimum average intensity.

(j) The light unit shall be installed so that the main or innermost beam, as applicable, is aligned within a one-half degree of the specified requirement.

191.APP-B.16 High-intensity taxiway centre line (15 m spacing), no-entry bar, and stop bar lights in straight sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required and where large offsets can occur

Figure APP-B.17: Isocandela diagram for high-intensity taxiway centre line (15 m spacing), no-entry bar and stop bar lights in straight sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required and where large offsets can occur



Source: ICAO Annex 14 Volume 1

(a) These beam coverages allow cockpit displacement from the centre line up to distances of 12 m and are designed to be used before and after curves.

(b) Figure APP.B-17 shows the intensities in green and yellow lights for taxiway centre line lights, yellow for runway guard lights, and red for stop bar lights.

(c) The minimum allowable light intensities are shown in Figure APP.B-12. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP.B-21 and using the intensity values measured at all grid points located within and on the perimeter of the main beam rectangle. The average value is the arithmetic mean of the light intensities measured at all considered grid points.

(d) When the lighting fixture is aimed correctly, no deviations in the main beam or the innermost beam are acceptable.

(e) Except for curves, horizontal angles are measured concerning the vertical plane through the taxiway centre line.

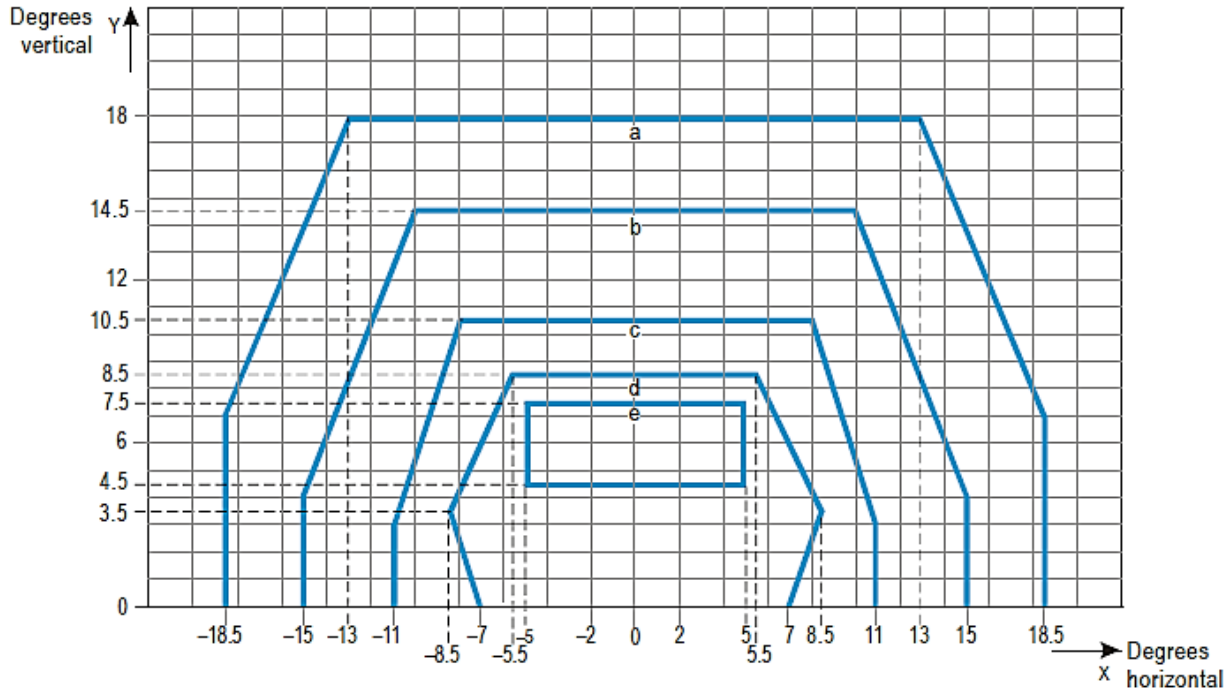
(f) Vertical angles are measured from the longitudinal slope of the taxiway.

(g) The significance of proper maintenance cannot be overstated. The intensity, either average where applicable or as specified on the corresponding isocandela curves, shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to keep light output close to the specified minimum average intensity.

(h) The light unit shall be installed so that the main or innermost beam, as applicable, is aligned within a one-half degree of the specified requirement.

191.APP-B.17 High-intensity taxiway centre line (15 m spacing), no-entry bar and stop bar lights in straight sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required

Figure APP-B.18: Isocandela diagram for high-intensity taxiway centre line (15 m spacing), no-entry bar, and stop bar lights in straight sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required



Source: ICAO Annex 14 Volume 1

Curve	a	b	c	d	e
Intensity (cd)	8	20	100	450	1800

(a) These beam coverages usually are sufficient and allow for a standard displacement of the cockpit in relation to the outer main gear wheel on the taxiway edge.

(b) Figure APP.B-18 shows the intensities in green and yellow lights for taxiway centre line lights, yellow for runway guard lights, and red for stop bar lights.

(c) The minimum allowable light intensities are shown in Figure APP.B-12. The average intensity of the main beam is calculated by establishing grid points as shown in Figure

APP.B-21 and using the intensity values measured at all grid points located within and on the perimeter of the main beam rectangle. The average value is the arithmetic mean of the light intensities measured at all considered grid points.

(d) When the lighting fixture is aimed correctly, no deviations in the main beam or the innermost beam are acceptable.

(e) Except for curves, horizontal angles are measured concerning the vertical plane through the taxiway centre line

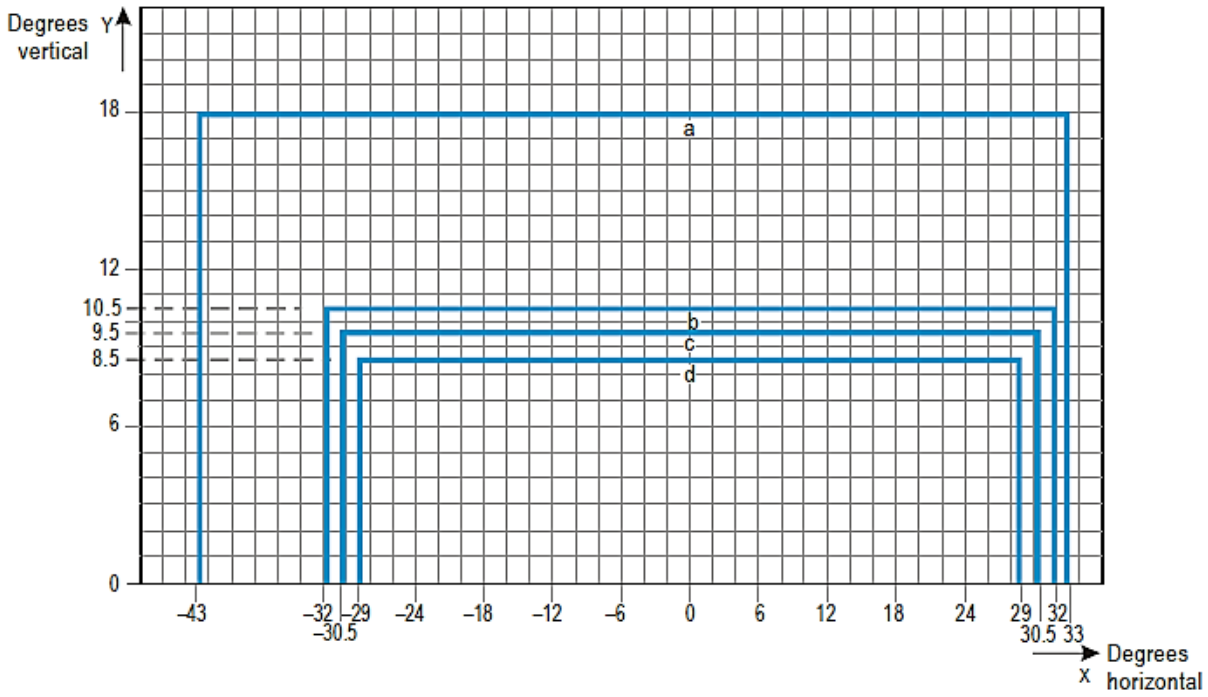
(f) Vertical angles are measured from the longitudinal slope of the taxiway.

(g) The significance of proper maintenance cannot be overstated. The intensity, either average where applicable or as specified on the corresponding isocandela curves, shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to keep light output close to the specified minimum average intensity.

(h) The light unit shall be installed so that the main or innermost beam, as applicable, is aligned within a one-half degree of the specified requirement.

191.APP-B.18 High-intensity taxiway centre line (7.5 m spacing), no-entry bar and stop bar lights in curved sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required

Figure APP-B.19: Isocandela diagram for high-intensity taxiway centre line (7.5 m spacing), no-entry bar, and stop bar lights in curved sections intended for use in an advanced surface movement guidance and control system where higher light intensities are required



Source: ICAO Annex 14 Volume 1

Curve	a	b	c	d
Intensity (cd)	8	100	200	400

(a) Toe-in 17 degrees concerning the tangent of the curve for lights on curves.

(b) Figure APP.B-19 shows the intensities in green and yellow lights for taxiway centre line lights, yellow for runway guard lights, and red for stop bar lights.

(c) The minimum allowable light intensities are shown in Figure APP.B-12. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP.B-21 and using the intensity values measured at all grid points located within and on the perimeter of the main beam rectangle. The average value is the arithmetic mean of the light intensities measured at all considered grid points.

(d) When the lighting fixture is aimed correctly, no deviations in the main beam or the innermost beam are acceptable.

(e) Except for curves, horizontal angles are measured concerning the vertical plane through the taxiway centre line

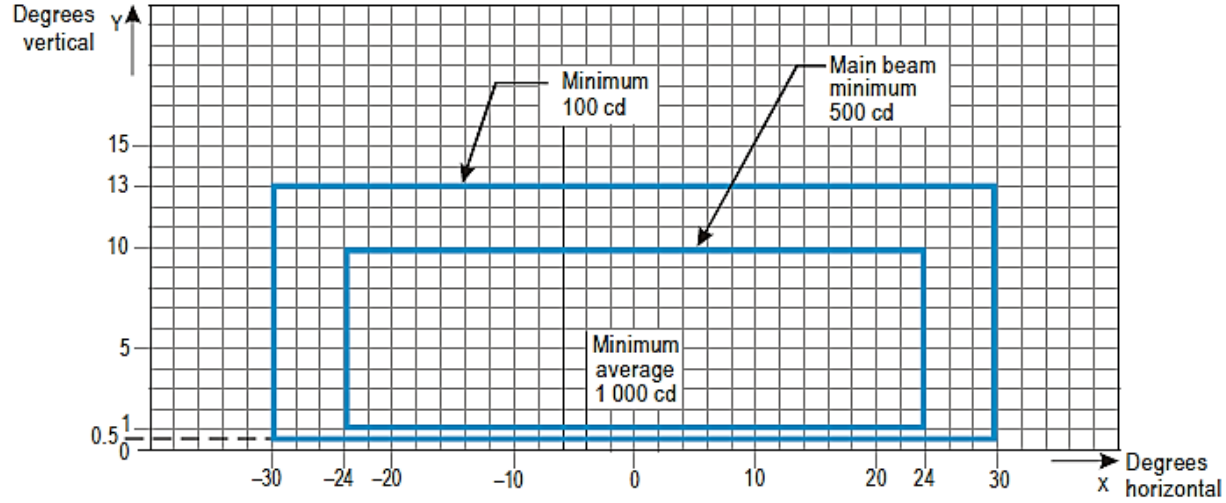
(f) Vertical angles are measured from the longitudinal slope of the taxiway.

(g) The significance of proper maintenance cannot be overstated. The intensity, either average where applicable or as specified on the corresponding isocandela curves, shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to keep light output close to the specified minimum average intensity.

(h) The light unit shall be installed so that the main or innermost beam, as applicable, is aligned within a one-half degree of the specified requirement.

191.APP-B.19 High-intensity runway guard lights, Configuration B

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



Source: ICAO Annex 14 Volume 1

(a) The light intensity is specified as if the lights were fixed for incandescent lamps, even though the lights flash during regular operation.

(b) Figure APP.B-20 shows the intensities in green and yellow lights for taxiway centre line lights, yellow for runway guard lights, and red for stop bar lights.

(c) The minimum allowable light intensities are shown in Figure APP.B-12. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP.B-21 and using the intensity values measured at all grid points located within and on the perimeter of the main beam rectangle. The average value is the arithmetic mean of the light intensities measured at all considered grid points.

(d) When the lighting fixture is aimed correctly, no deviations in the main beam or the innermost beam are acceptable.

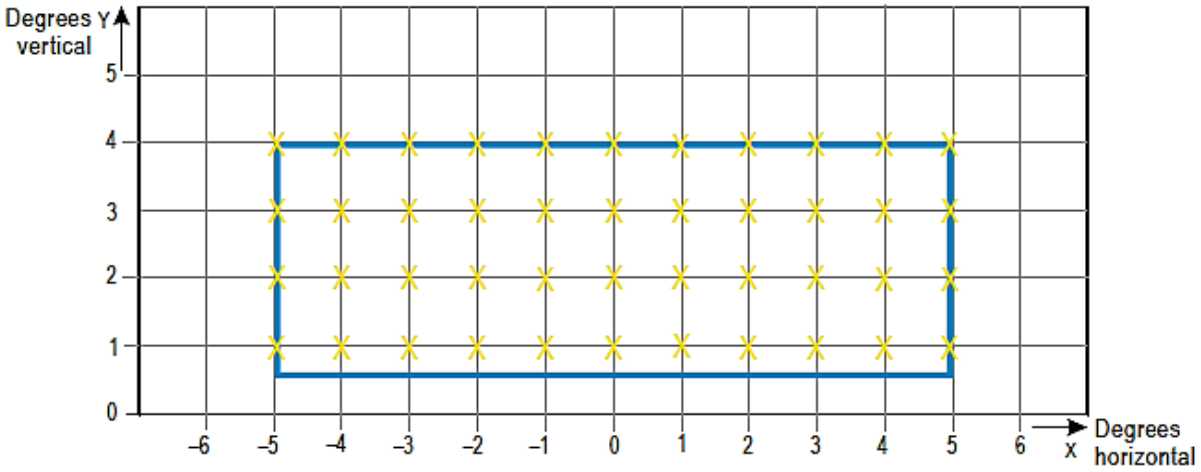
(e) Except for curves, horizontal angles are measured concerning the vertical plane through the taxiway centre line

(f) Vertical angles are measured from the longitudinal slope of the taxiway.

(g) The significance of proper maintenance cannot be overstated. The intensity, either average where applicable or as specified on the corresponding isocandela curves, shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to keep light output close to the specified minimum average intensity.

(h) The light unit shall be installed in such a way that the main beam or innermost beam, as applicable, is aligned within a one-half degree of the specified requirement

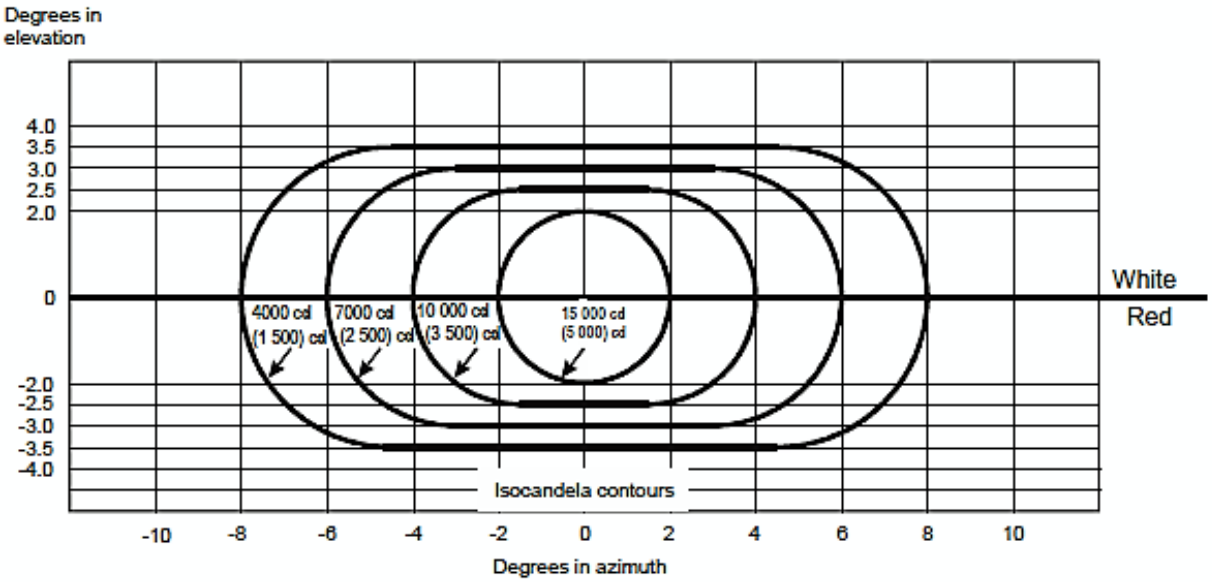
Figure APP.B-21: Grid points to be used for calculation of the average intensity of taxiway centre line and stop bar lights



Source: ICAO Annex 14 Volume 1

191.APP-B.20 Light intensity distribution of PAPI and APAPI

Figure APP.B-22: Light intensity distribution of PAPI and APAPI



Source: ICAO Annex 14 Volume 1

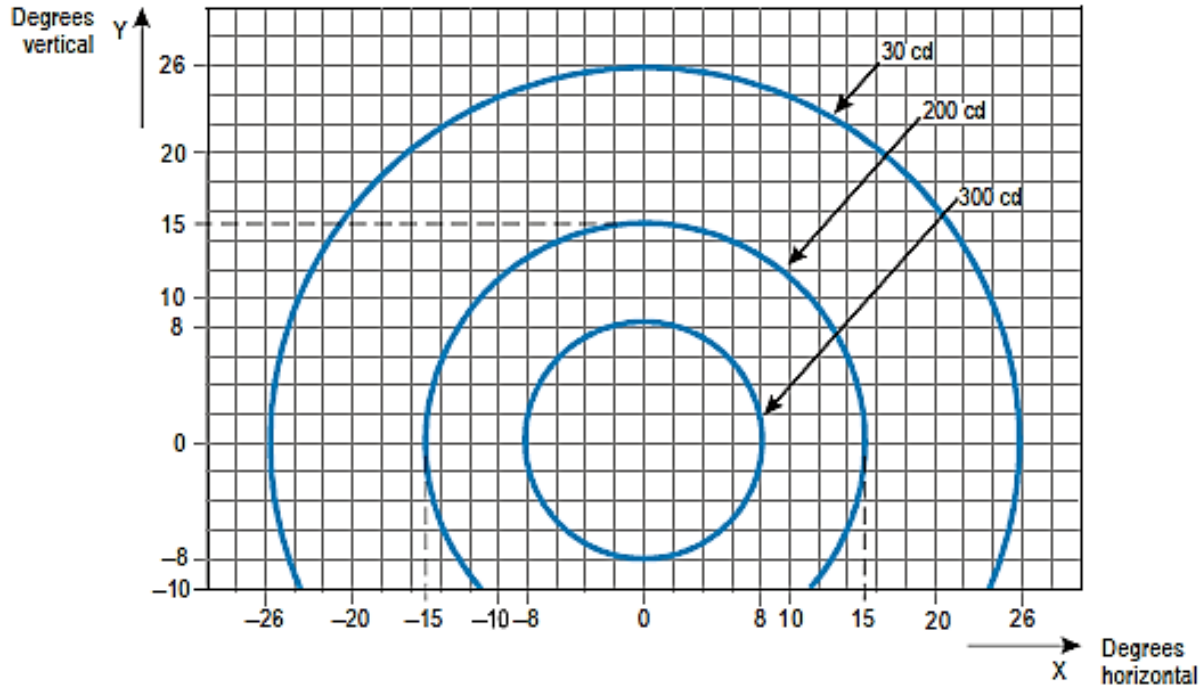
(a) These curves represent the minimum red light intensities.

(b) The intensity value in the white sector of the beam is at least 2 and no more than 6.5 times the intensity value in the red sector.

(c) APAPI intensity values are indicated between brackets.

191.APP-B.21 Light in low-intensity runway guard lights Configuration A

Figure APP.B-23: Isocandela diagram for each light in low-intensity runway guard lights, Configuration A



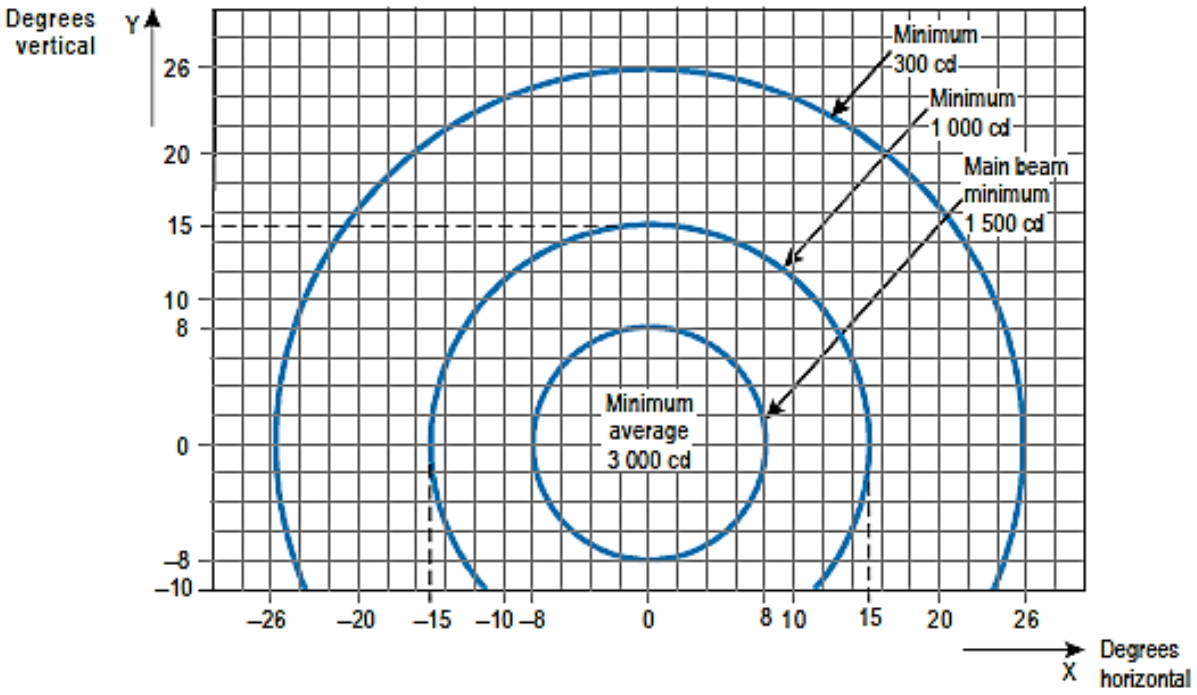
Source: ICAO Annex 14 Volume 1

(a) The light intensity is specified as if the lights were fixed for incandescent lamps, even though the lights flash during regular operation.

(b) The specified intensities are in yellow light.

191.APP-B.22 Light in high-intensity runway guard lights Configuration A

Figure APP.B-24: Isocandela diagram for each light in high-intensity runway guard lights, Configuration A



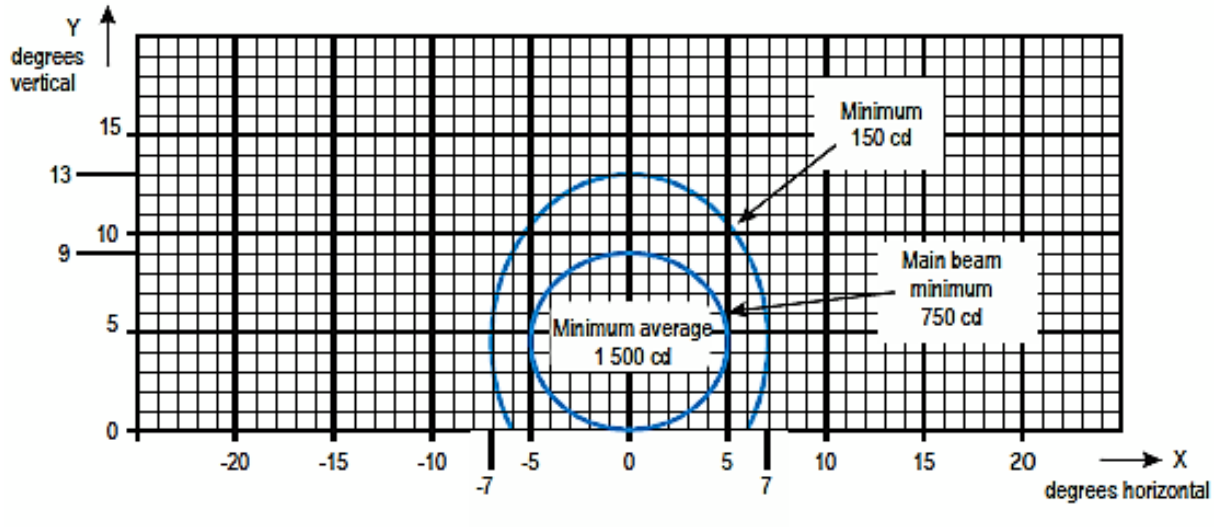
Source: ICAO Annex 14 Volume 1

(a) Even though the lights flash during regular operation, the light intensity is specified as fixed incandescent lamps.

(b) These intensities are specified in yellow light.

191.APP-B.23 Take-off and hold lights (THL) (red light)

Figure APP.B-25: Isocandela diagram for take-off and hold lights (THL) (red light)



Source: ICAO Annex 14 Volume 1

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

a	5.0	7.0
b	4.5	8.5

(b) The ellipses of each figureare symmetrical about the common vertical and horizontal axes.

(c) The minimum allowable light intensities are shown in Figure APP-B.25. The average intensity of the main beam is calculated by establishing grid points as shown in Figure APP-B.11 and calculating the intensity values at all grid points located within and on the perimeter of the ellipse representing the main beam. The average value is the arithmetic mean of the light intensities that are measured at all grid points.

(d) No deviations in the main beam pattern are acceptable when the lighting fixture is aimed correctly.

(e) The beam coverages depicted in the figure provide the necessary guidance for approaches down to an RVR of 150 m and take-offs down to an RVR of 100 m.

(f) Horizontal angles are measured concerning the vertical plane along the centre line of the runway. The direction towards the runway centre line is considered positive for lights other than centre line lights. Vertical angles are calculated in relation to the horizontal plane.

(g) When inset lights are used in place of elevated lights for approach centre line lights and crossbars, as on a runway with a displaced threshold, the intensity requirements can be met by installing two or three fittings (lower intensity) at each position.

(h) The significance of proper maintenance cannot be overstated. The average intensity shall never fall below 50% of the value shown in the figures, and airport authorities shall strive to maintain a light output level close to the specified minimum average intensity.

(i) The light unit shall be installed so that the main beam is aligned to within a one-half degree of the specified requirement.

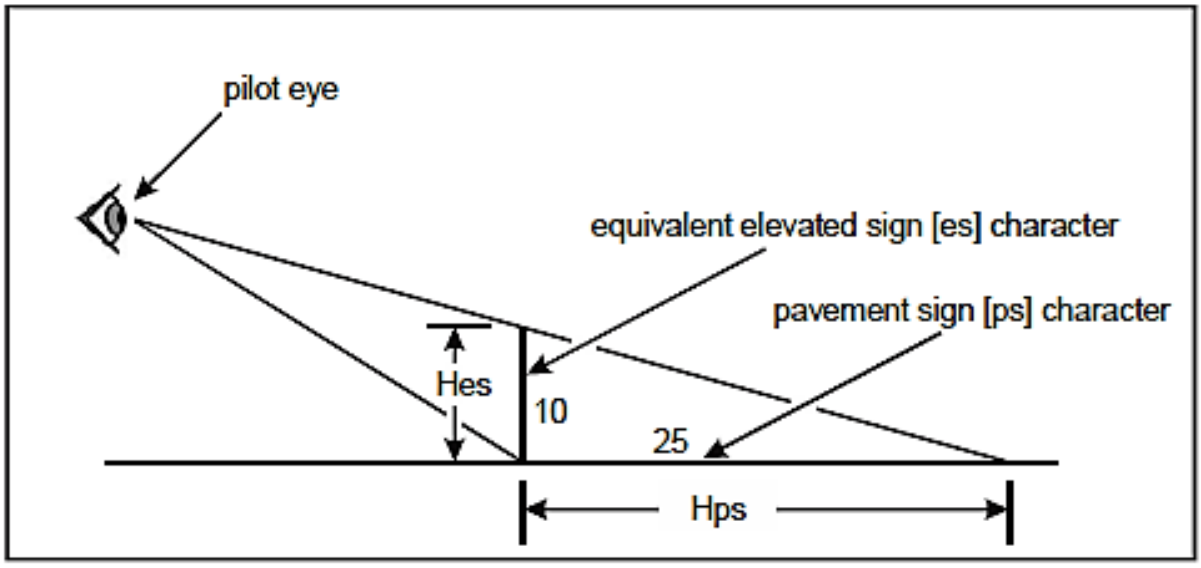
Appendix C – Mandatory instruction markings and information markings

Refer to OTAR 191.175 and 191.177 for details on the application, location, and characteristics of required instruction and information markings.

This appendix specifies the shape and proportions of the letters, numbers, and symbols used for mandatory instruction and information markings on a grid.

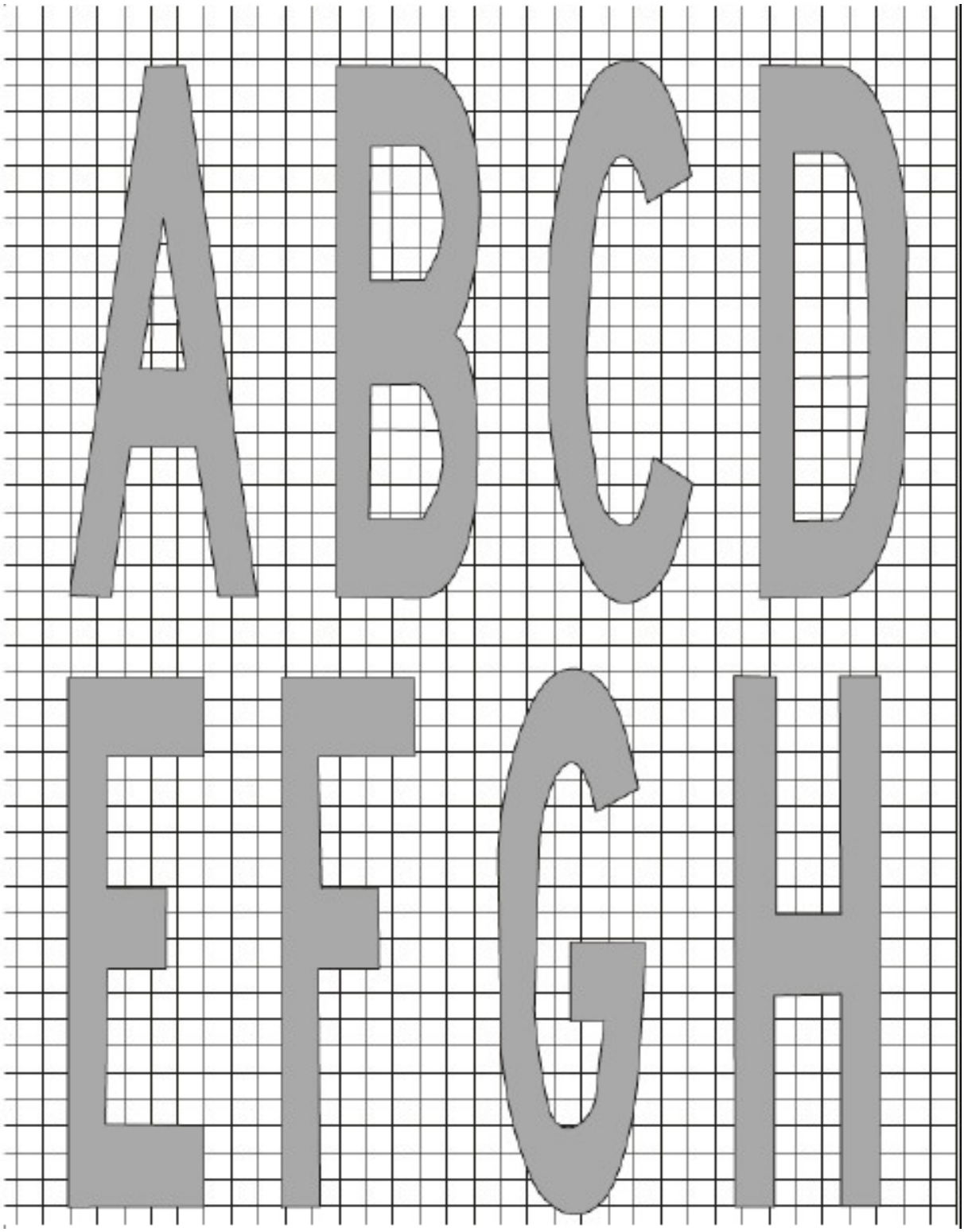
As shown in Figure APP.C-1, the mandatory instruction markings and information markings on pavements are formed as if shadowed (stretched) by a factor of 2.5 from the characters of an equivalent elevated sign. However, the shadowing only affects the vertical dimension. Therefore, the spacing of characters for pavement marking is obtained by first determining the equivalent character height of an elevated sign and then proportioning from the values given in Table APP.D-T1.

Figure APP.C-1: Instruction and information on pavement markings



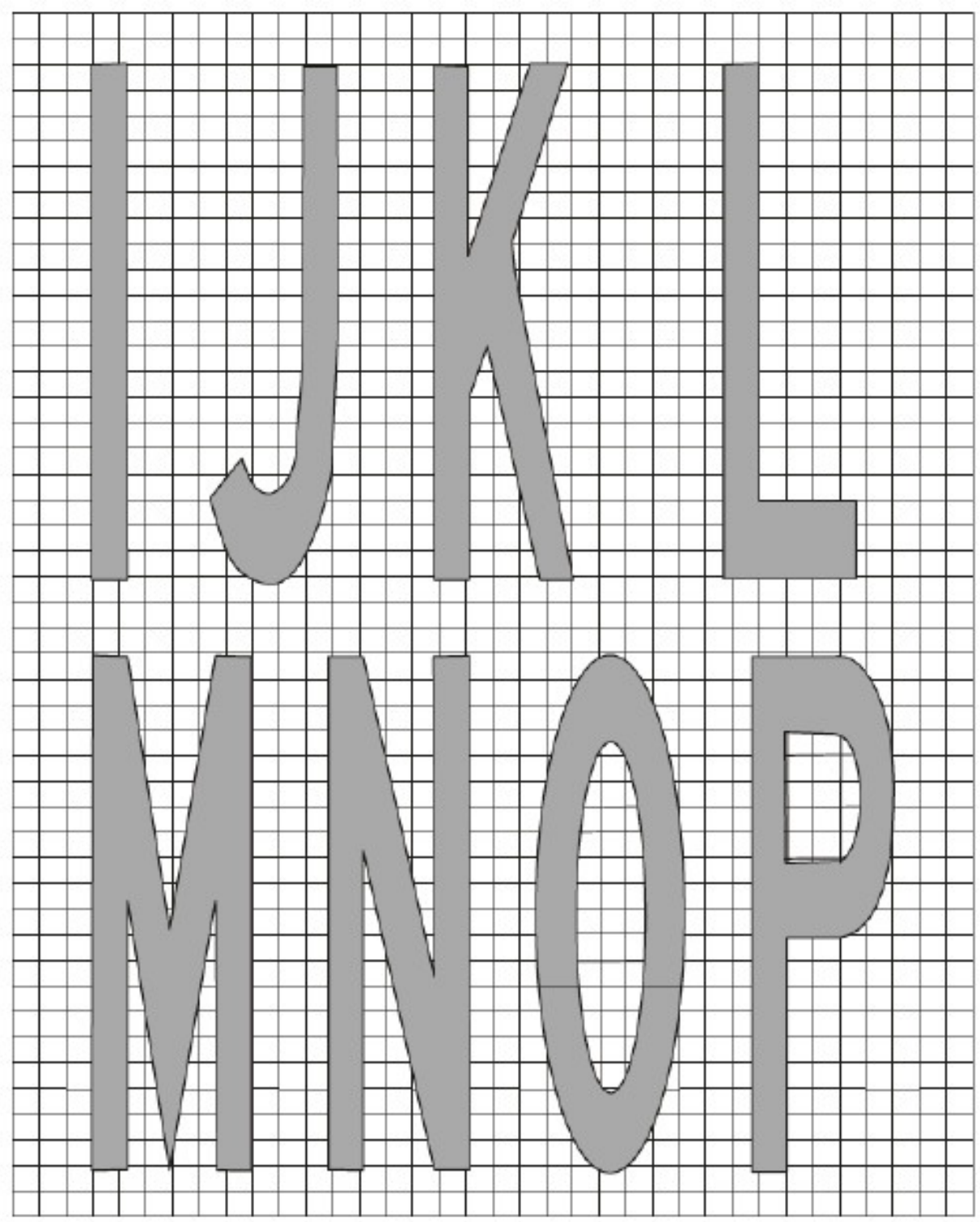
Source: ICAO Annex 14 Volume 1

Figure APP.C-2: Mandatory instruction markings



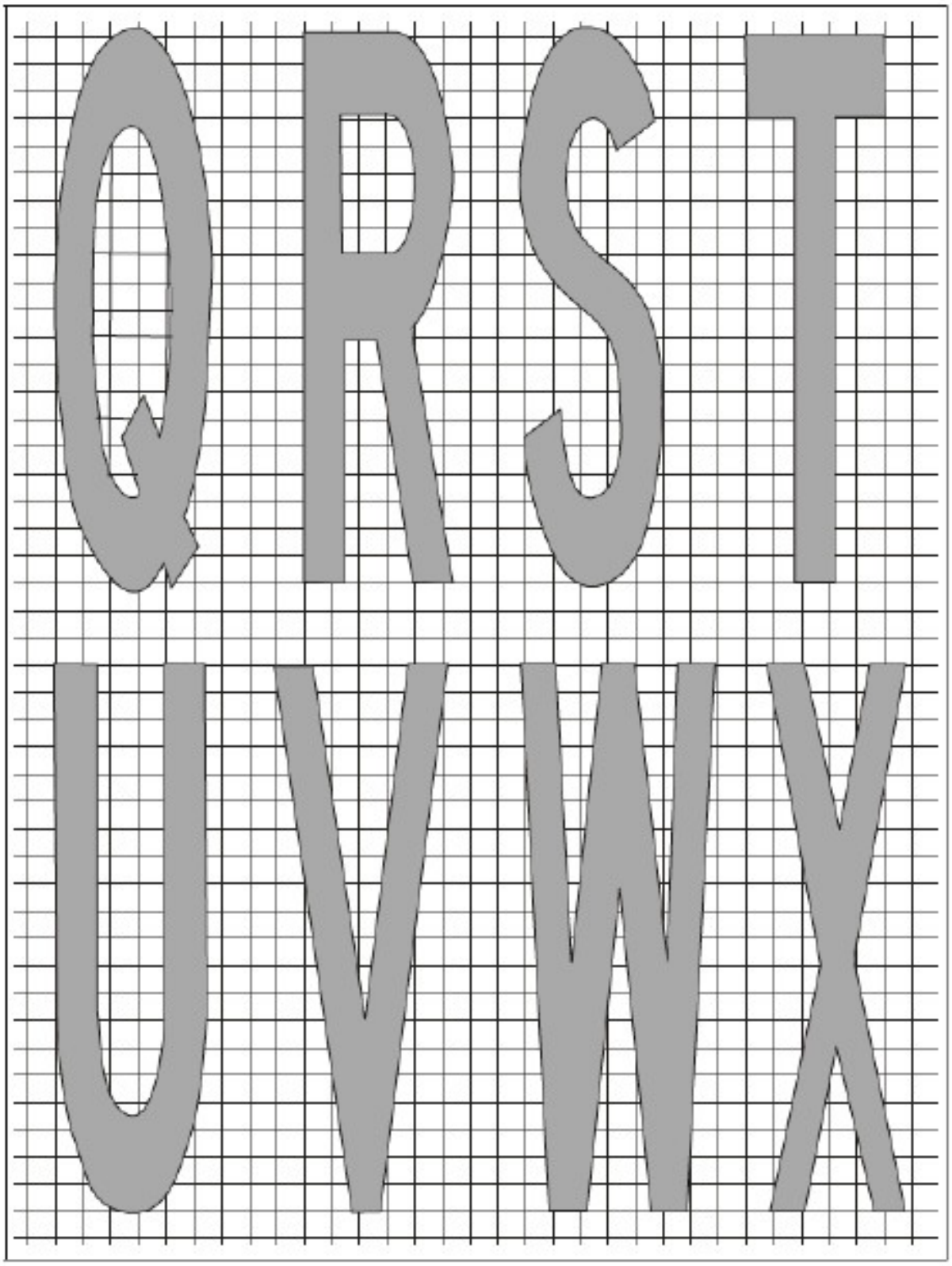
Source: CAP168

Figure APP.C-3: Mandatory instruction markings (cont.)



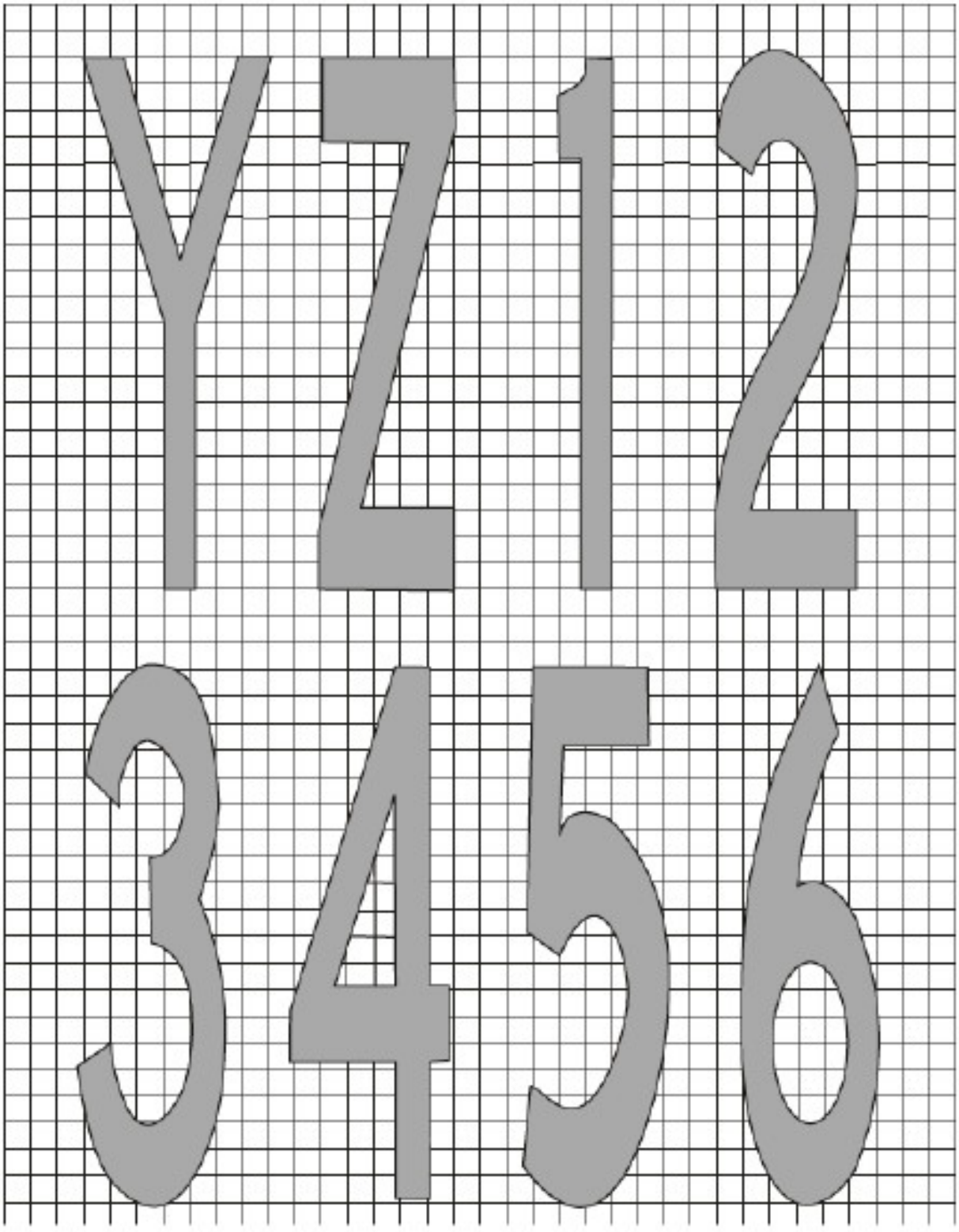
Source: CAP168

Figure APP.C-4: Mandatory instruction markings (cont.)



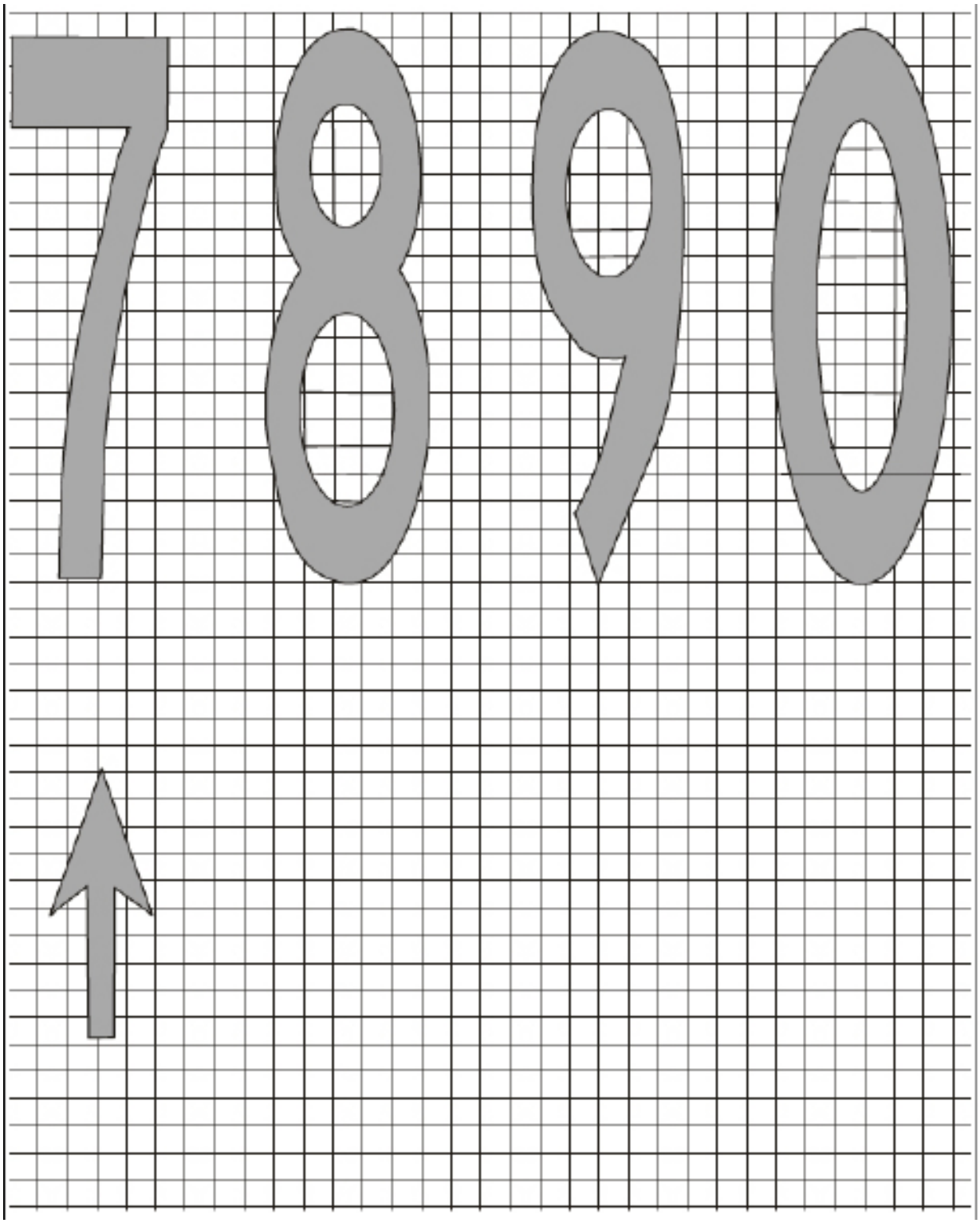
Source: CAP168

Figure APP.C-5: Mandatory instruction markings (cont.)



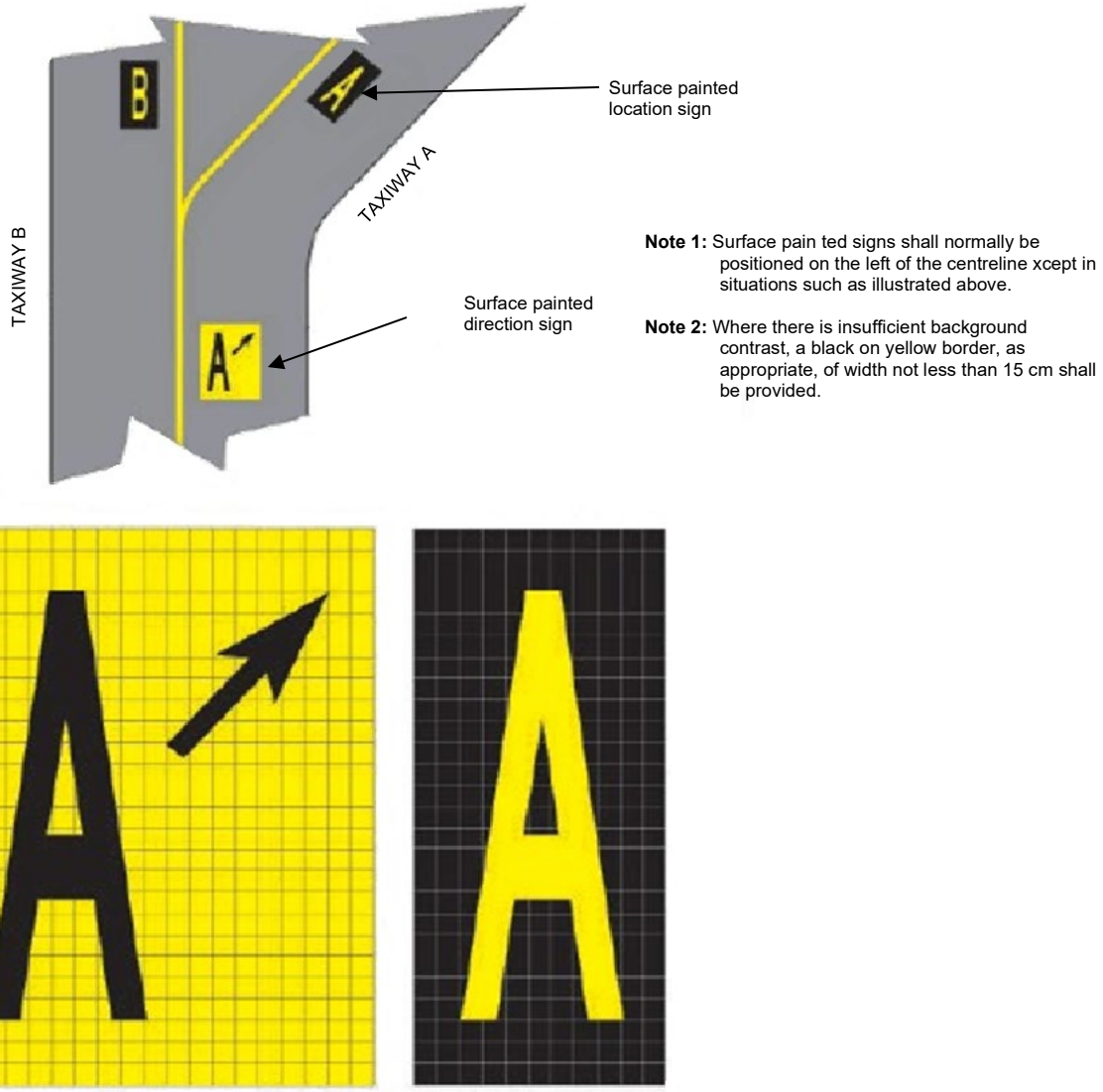
Source: CAP168

Figure APP.C-5: Mandatory instruction markings (cont.)



Source: CAP168

Figure APP.C-6: Pavement markings for taxiways and aprons – examples of surface-painted signs



Note: The grid is shown only to illustrate sign size in relation to character proportions and should not show on the completed sign.

Appendix D – Requirements concerning the design of taxiing guidance signs

Specifications on the application, location, and characteristics of signs can be found in Subpart L.

(a) Inscription heights shall adhere to the following requirements:

Runway code number	Minimum character height		
	Mandatory instruction sign	Information sign	
		Runway exit and runway vacated signs	Other signs
1 or 2	300 mm	300 mm	200 mm
3 or 4	400 mm	400 mm	300 mm

When a taxiway location sign is installed in conjunction with a runway designation sign (see OTAR 191.253(r)), the character size shall conform to the requirements for mandatory instruction signs.

(b) The dimensions of the arrows shall be as follows:

Legend height	Stroke
200 mm	32 mm
300 mm	48 mm
400 mm	64 mm

(c) Stroke width for a single letter shall be as follows:

Legend height	Stroke
200 mm	32 mm
300 mm	48 mm
400 mm	64 mm

(d) The brightness of signs shall be as follows:

(1) When operations are carried out in RVR less than 800 m, the average sign luminance shall be at least:

Red 30 cd/m2

Yellow 150 cd/m2

White 300 cd/m2

(2) When operations are carried out in accordance with OTAR 191.249 (g) (2) and (3), as well as OTAR 191.249 (h), the average sign luminance shall be at least:

Red 10 cd/m2

Yellow 50 cd/m2

White 100 cd/m2

Note: There will be some degradation in sign performance when the RVR is less than 400 m.

(e) Anluminance ratio of a mandatory signs between red and white elements shall be between 1:5 and 1:10.

(f) The average luminance of the sign is calculated by establishing grid points as shown in Figure APP.D-1 and using the luminance values measured at all grid points within the rectangle of the sign.

(g) The average value is the arithmetic mean of the luminance values that are measured at all grid points.

Note: The Aerodrome Design Manual (Doc 9157), Part 4, contains instructions for measuring the average luminance of a sign.

(h) The luminance value ratio of adjacent grid points shall not exceed 1.5:1. The ratio of luminance values of adjacent grid points on the sign face where the grid spacing is 7.5 cm shall not exceed 1.25:1. The maximum to minimum luminance value ratio over the entire sign face shall not exceed 5:1.

(i) Characters, such as letters, numbers, arrows, and symbols, shall have the shapes shown in Figure APP.D-2. Character width and space between individual characters shall be determined as shown in Table Figure APP.D-T1.

(j) The face height of signs shall be as follows:

Legend height	Face height (min)
200 mm	300 mm
300 mm	450 mm
400 mm	600 mm

(k) The face width of signs shall be determined in accordance with Figure APP.D-5, except that where a mandatory instruction sign is provided on only one side of a taxiway, the face width shall not be less than:

(1) 1.94 m where the code number is 3 or 4; and

(2) 1.46 m, where the code number is 1 or 2.

Note: The Aerodrome Design Manual (Doc 9157), Part 4, contains additional information on determining the face width of a sign.

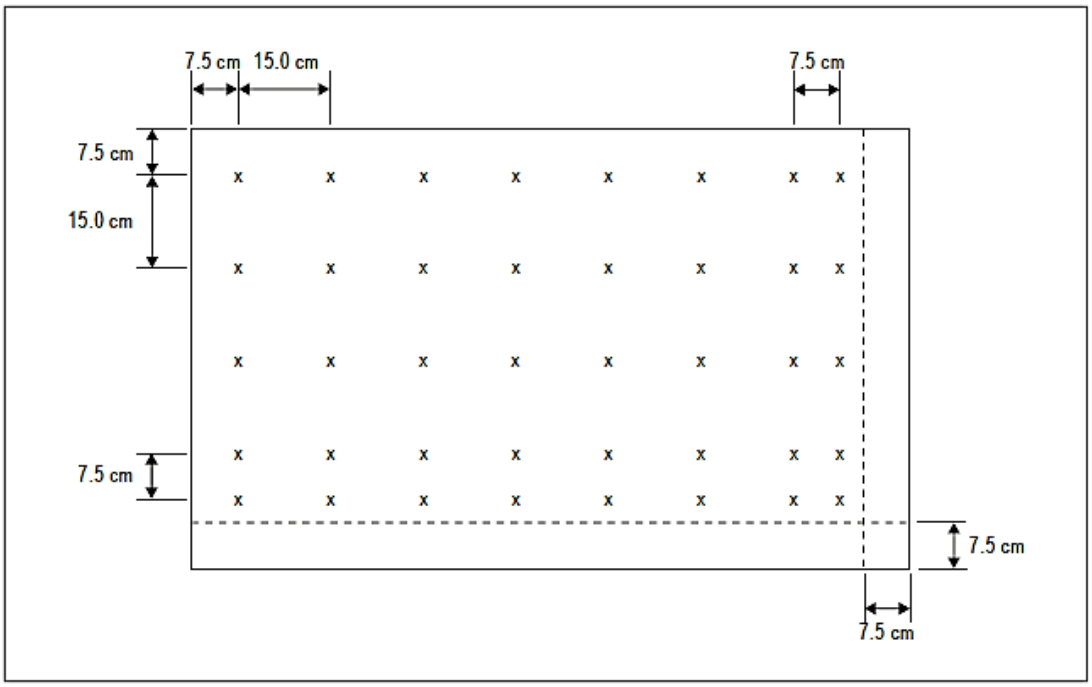
(l) Borders:

(1) The width of the black vertical delineator between adjacent direction signs shall be approximately 0.7 of the stroke width.

(2) A standalone location of theyellow border of the sign shall be approximately 0.5 stroke width.

(3) The colours of the signs shall be in accordance with the specifications in Appendix A.

Figure APP.D-1: Grid points for calculating the average luminance of a sign



Source: ICAO Annex 14 Volume 1

Note 1: The average luminance of a sign is calculated by placing grid points on a sign face with typical inscriptions and a background of the appropriate colour (red for mandatory instruction signs and yellow for direction and destination signs), as shown below:

(i) Begin at the top left corner of the sign face and measure 7.5 cm from the left edge and the top of the sign face.

(ii) Draw a grid with 15 cm horizontal and vertical spacing from the reference grid point. Grid points within 7.5 cm of the edge of the sign face shall be avoided.

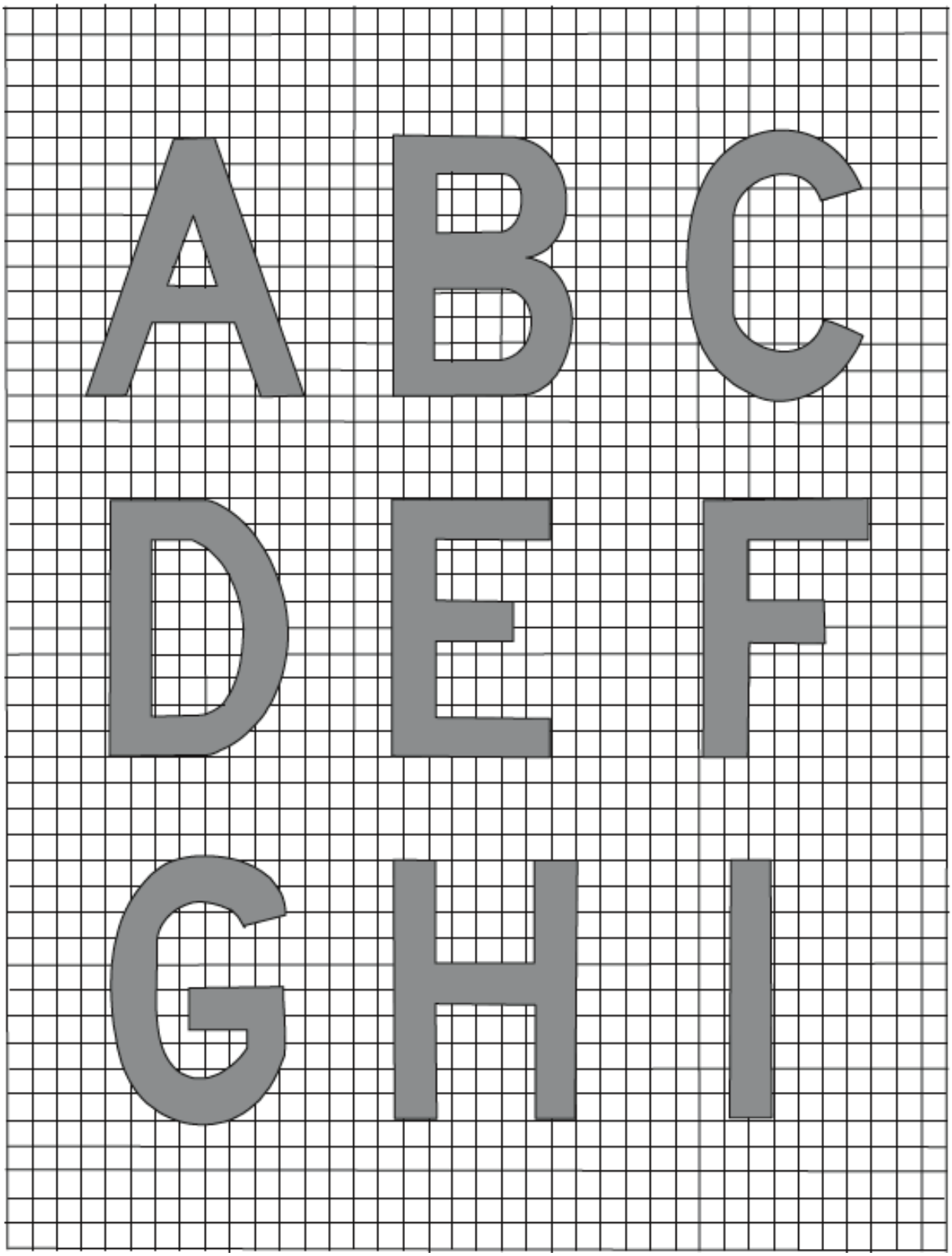
(iii) Where the last point in a row/column of grid points is between 22.5 cm and 15 cm from the edge of the sign face (inclusive), an additional point of 7.5 cm from this point shall be added.

(iv) If a grid point falls on the boundary of a character and the background, it shall be slightly shifted so that it is completely outside the character.

Note 2: More grid points may be needed to ensure that each character has at least five evenly spaced grid points.

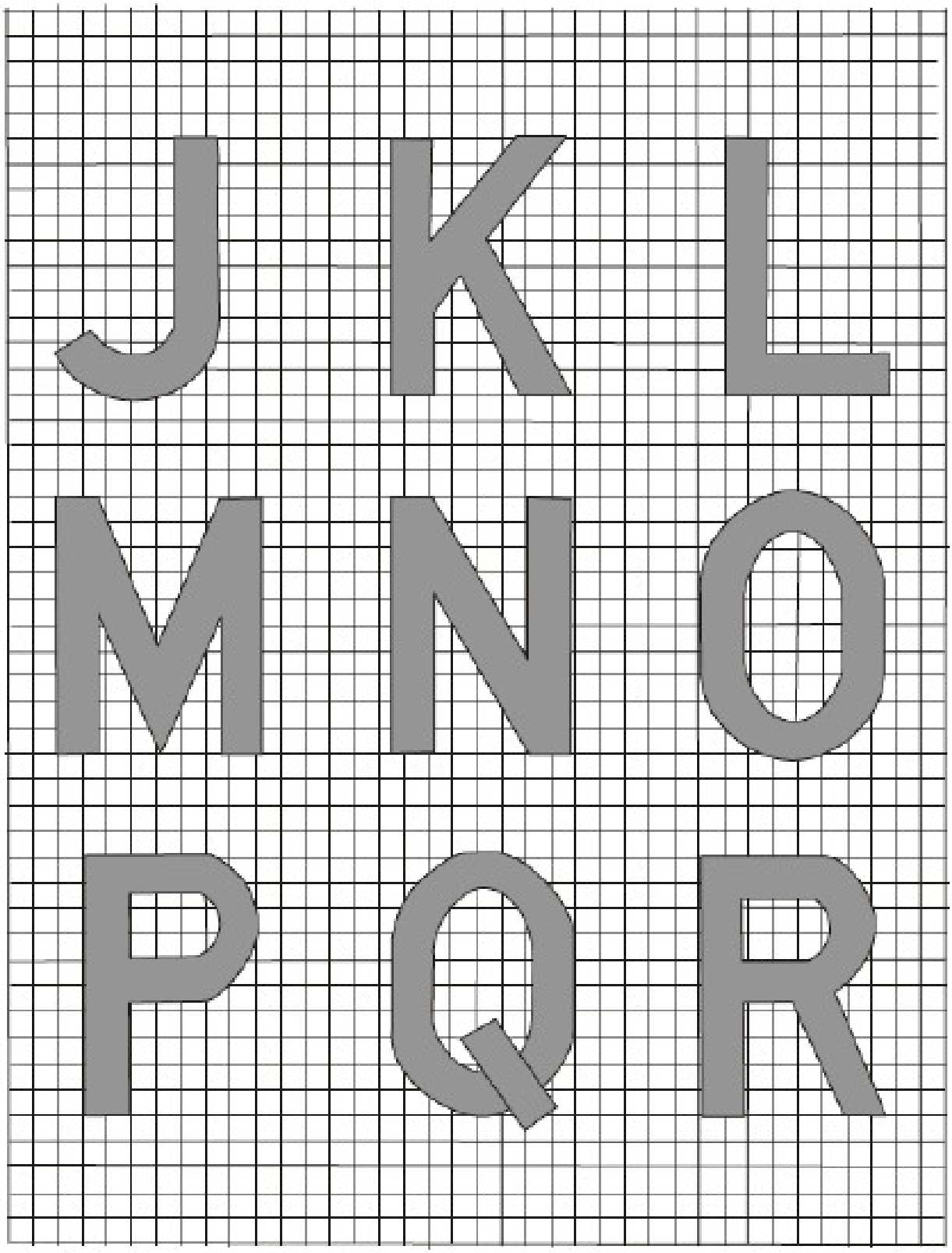
Note 3: When a single unit contains two types of signs, each type shall have its grid.

Figure APP.D-2: Forms of characters



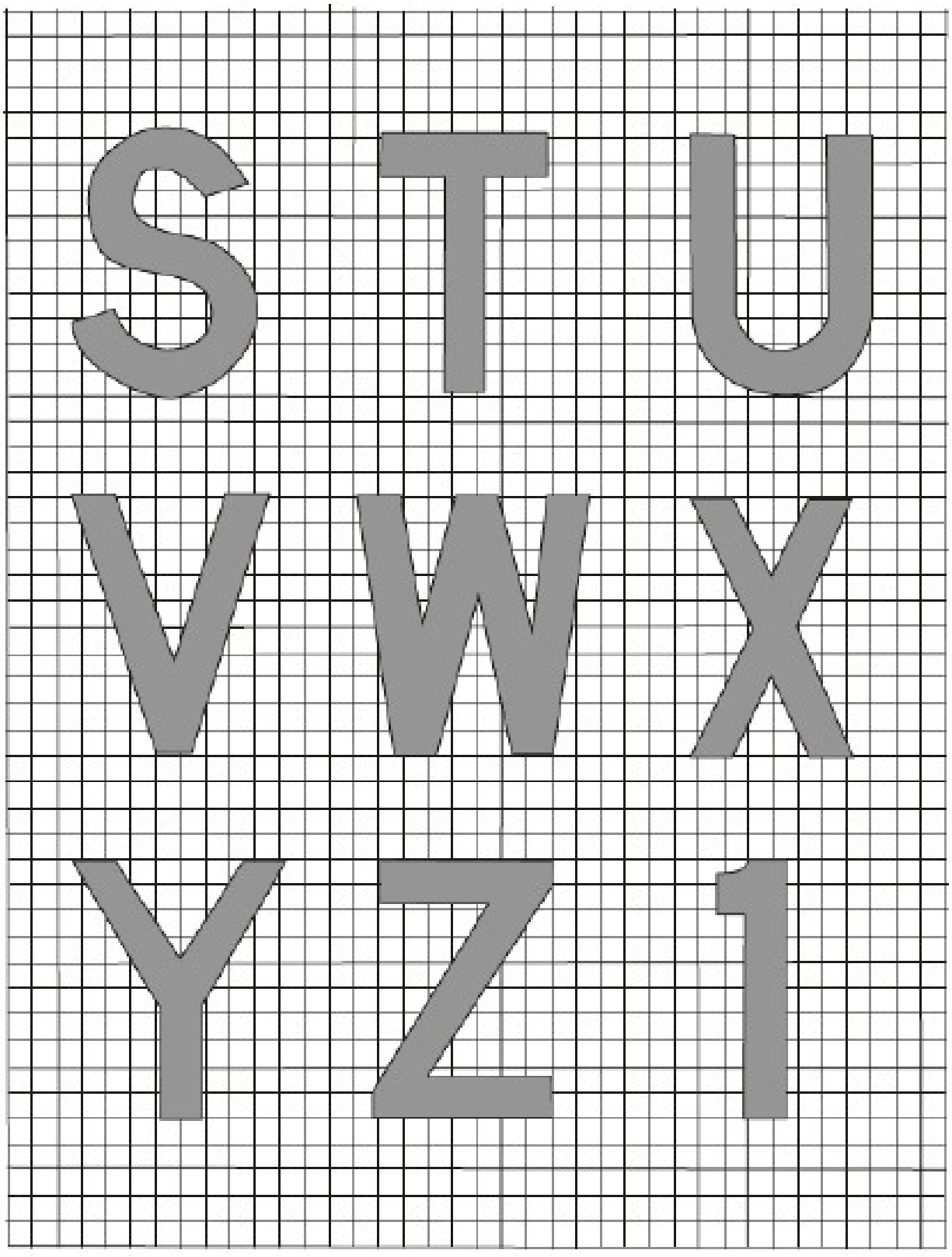
Source: CAP168

Figure APP.D-2: Forms of characters (cont.)



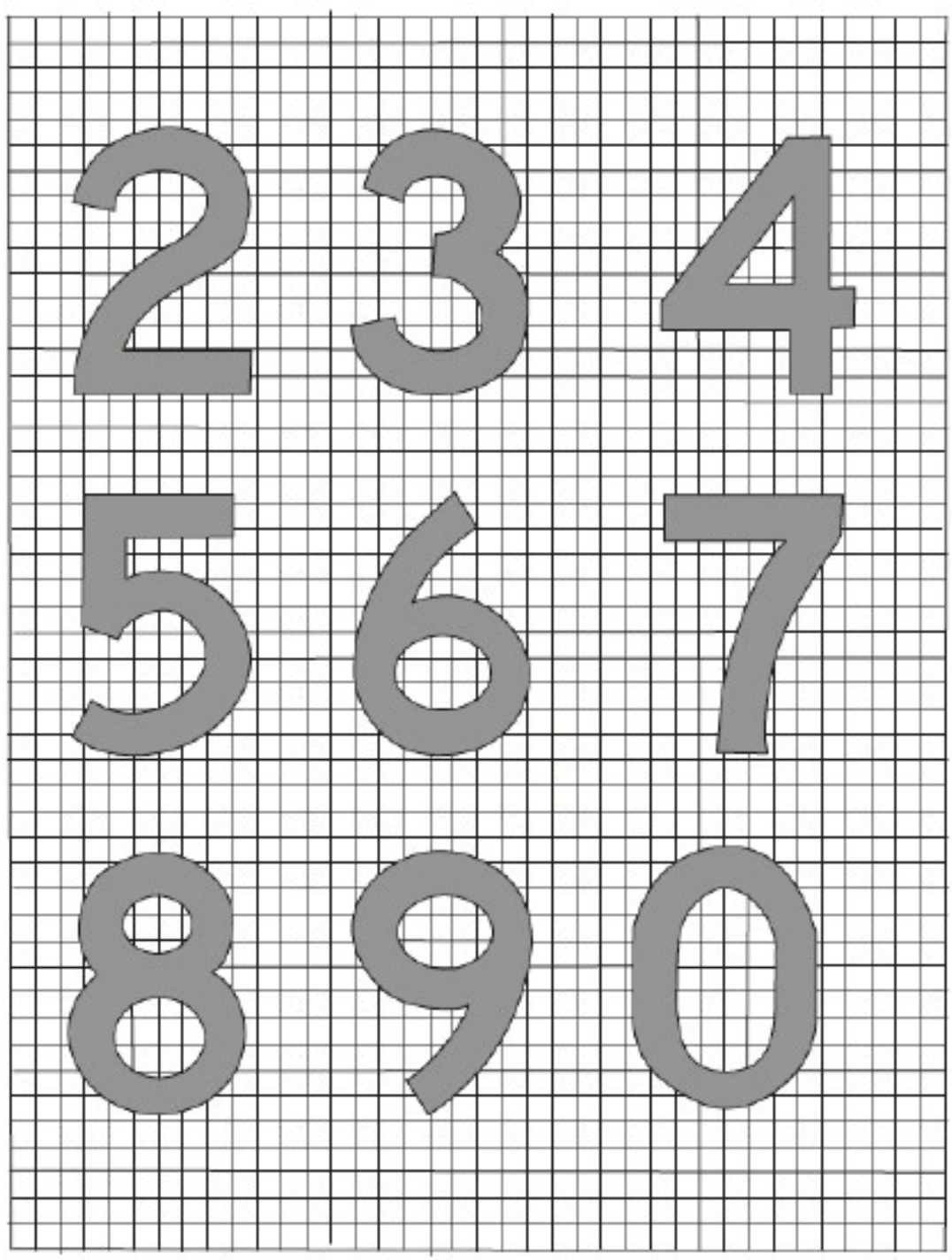
Source: CAP168

Figure APP.D-2: Forms of characters (cont.)



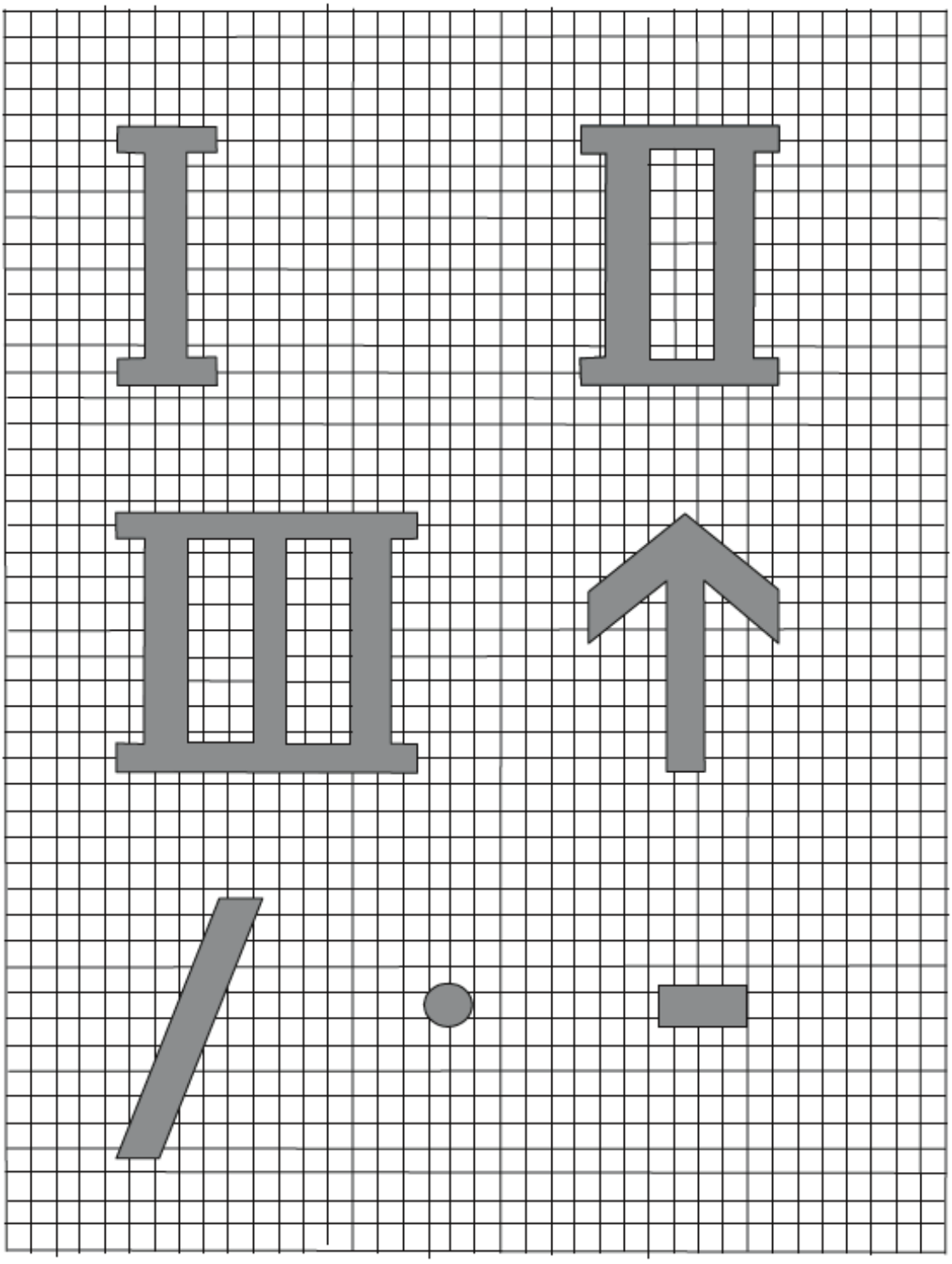
Source: CAP168

Figure APP.D-2: Forms of characters (cont.)



Source: CAP168

Figure APP.D-2: Forms of characters (cont.)

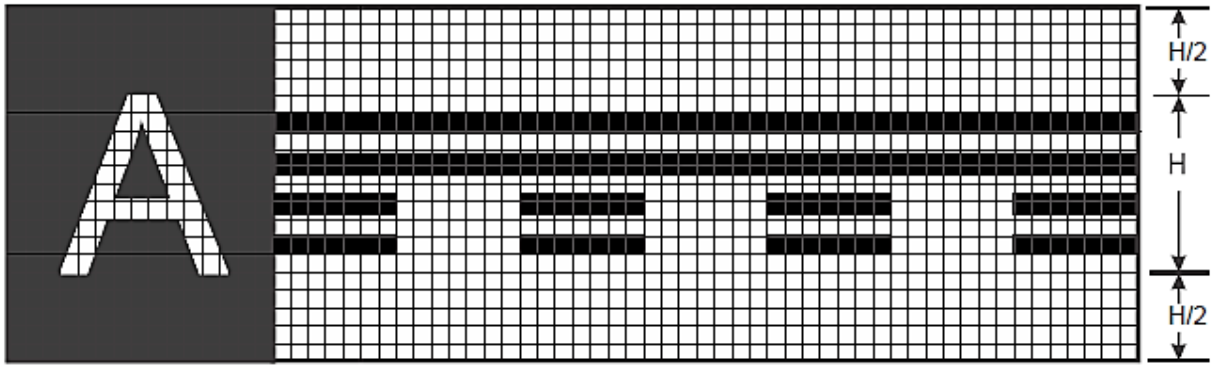


Source: CAP168

Note 1: The width of the arrow stroke, the diameter of the dot, and the width and length of the dash shall be proportional to the widths of the character strokes.

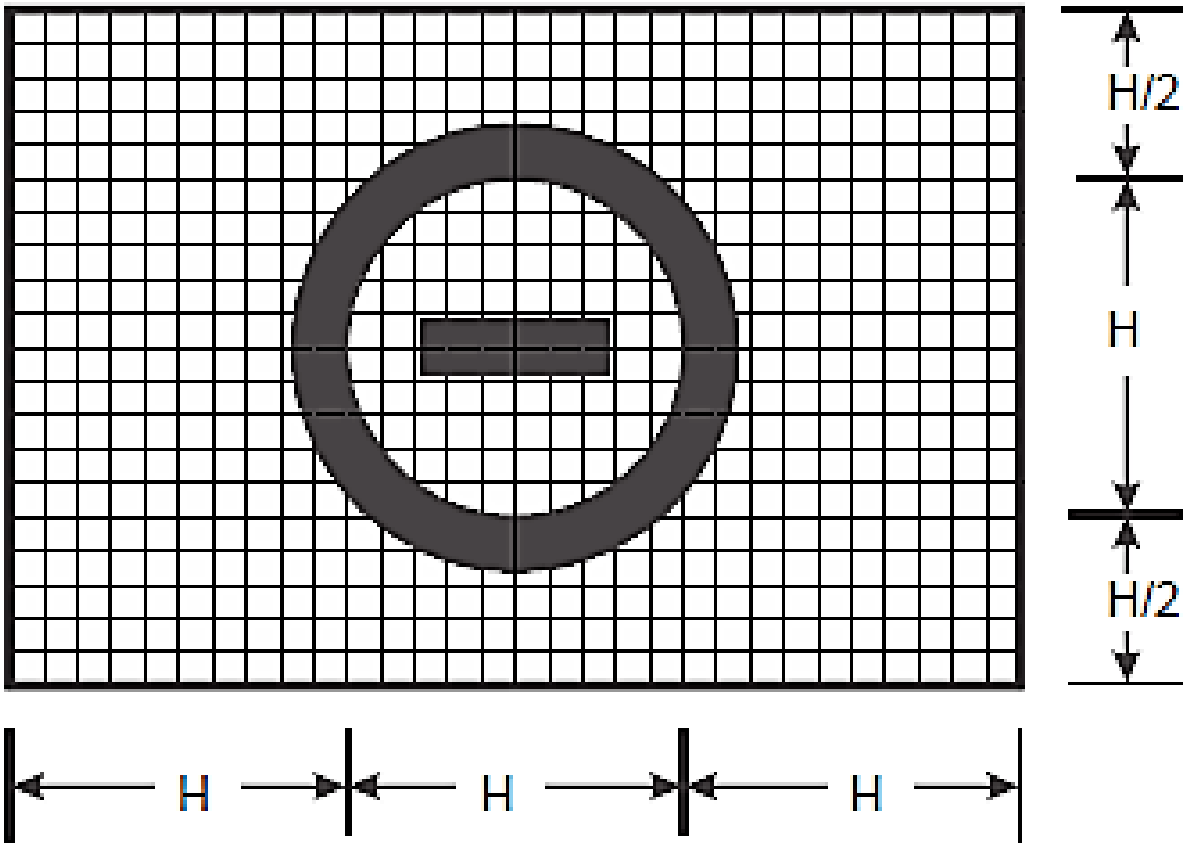
Note 2: Regardless of orientation, the arrow dimensions for a given sign size shall stay consistent.

Figure APP.D-3: Runway vacated sign (with typical location sign)



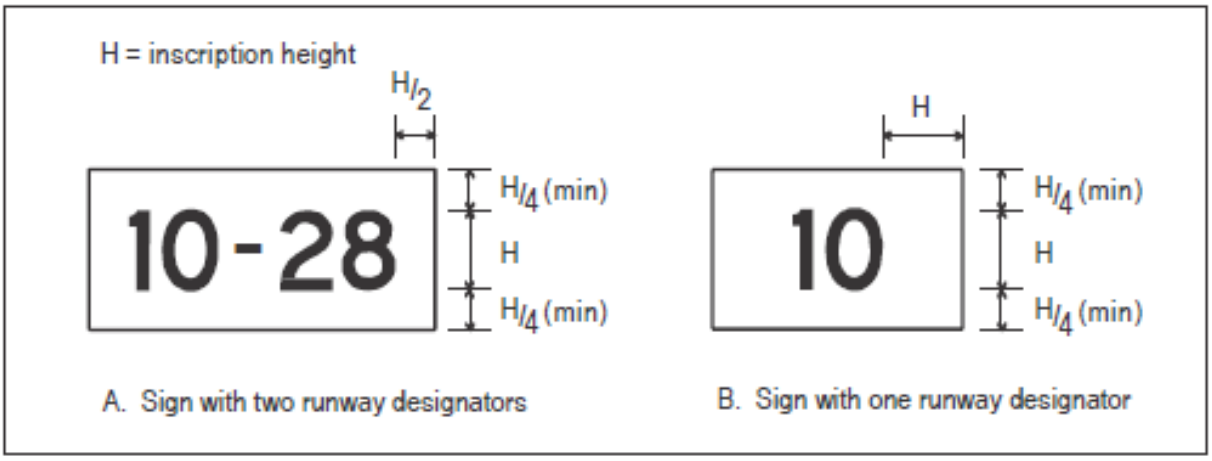
Source: ICAO Annex 14 Volume 1

Figure APP.D-4: NO ENTRY sign



Source: ICAO Annex 14 Volume 1

Figure APP.D-5: Sign dimensions



Note: "H" stands for the inscription height.

Table APP.D-T1: Letter and numeral widths and space between letters or numerals

a) Letter to letter code number			
Preceding Letter	Following Letter		
	B, D, E, F, H, I, K, L, M, N, P, R, U	C, G, O, Q, S, X, Z	A, J, T, V, W, Y
	Code number		
A	2	2	4
B	1	2	2
C	2	2	3
D	1	2	2
E	2	2	3
F	2	2	3
G	1	2	2
H	1	1	2
I	1	1	2
J	1	1	2
K	2	2	3
L	2	2	4
M	1	1	2
N	1	1	2
O	1	2	2
P	1	2	2
Q	1	2	2
R	1	2	2
S	1	2	2
T	2	2	4
U	1	1	2
V	2	2	4
W	2	2	4
X	2	2	3
Y	2	2	4
Z	2	2	3

b) Numeral to numeral code number			
Preceding Numeral	Following number		
	1, 5	2, 3, 6, 8, 9, 0	4, 7
	Code number		
1	1	1	2
2	1	2	2
3	1	2	2
4	2	2	4
5	1	2	2
6	1	2	2
7	2	2	4
8	1	2	2
9	1	2	2
0	1	2	2

c) Space between characters			
Code No.	Character height (mm)		
	200	300	400
	Space (mm)		
1	48	71	96
2	38	57	76
3	25	38	50
4	13	19	26

d) Width of letter			
Letter.	Letter height (mm		
	200	300	400
	Width (mm)		
A	170	255	340
B	137	205	274
C	137	205	274
D	137	205	274
E	124	186	248
F	124	186	248
G	137	205	274
H	137	205	274
I	32	48	64
J	127	190	254
K	140	210	280
L	124	186	248
M	157	236	314
N	137	205	274
O	143	214	286
P	137	205	274
Q	143	214	286
R	137	205	274
S	137	205	274
T	124	186	248
U	137	205	274
V	152	229	304
W	178	267	356
X	137	205	274
Y	171	257	342
Z	137	205	274

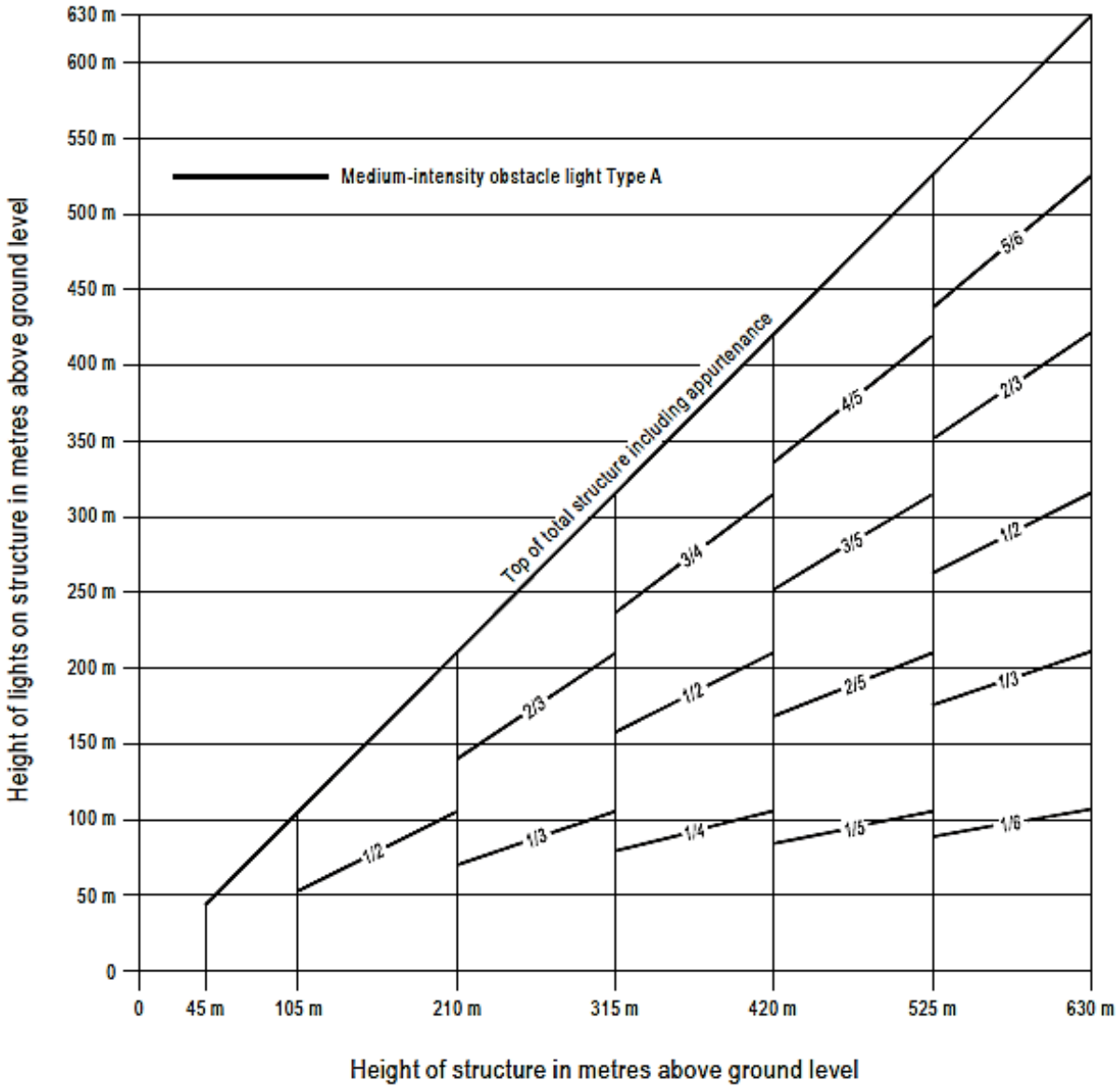
e) Width of numeral			
Numeral	Numeral height (mm		
	200	300	400
	Width (mm)		
1	50	74	98
2	137	205	274
3	137	205	274
4	149	224	298
5	137	205	274
6	137	205	274
7	137	205	274
8	137	205	274
9	137	205	274
0	143	214	286

INSTRUCTIONS

1. To find the correct SPACE between letters or numerals, take the code number from table a) or b) and insert the appropriate letter or numeral height into table c) for that code number.
2 The space between words or groups of characters forming an abbreviation or symbol shall be equal to 0.5 to 0.75 of the height of the characters used, unless an arrow is located with a single character, such as 'A ', in which case the space may be reduced to no less than a quarter of the height of the character to provide a good visual balance.
3. Code 1 is used when a numeric follows a letter or vice versa.
4. Code 1 is used when a hyphen, dot, or diagonal stroke precedes a character or vice versa.
5. For the intersection take-off sign, the height of the lowercase "m" is 0.75 of the height of the previous "0" (zero), and it is separated from the preceding "0" at code 1 for the character height of the numerals.

Appendix E – Location of lights on obstacles

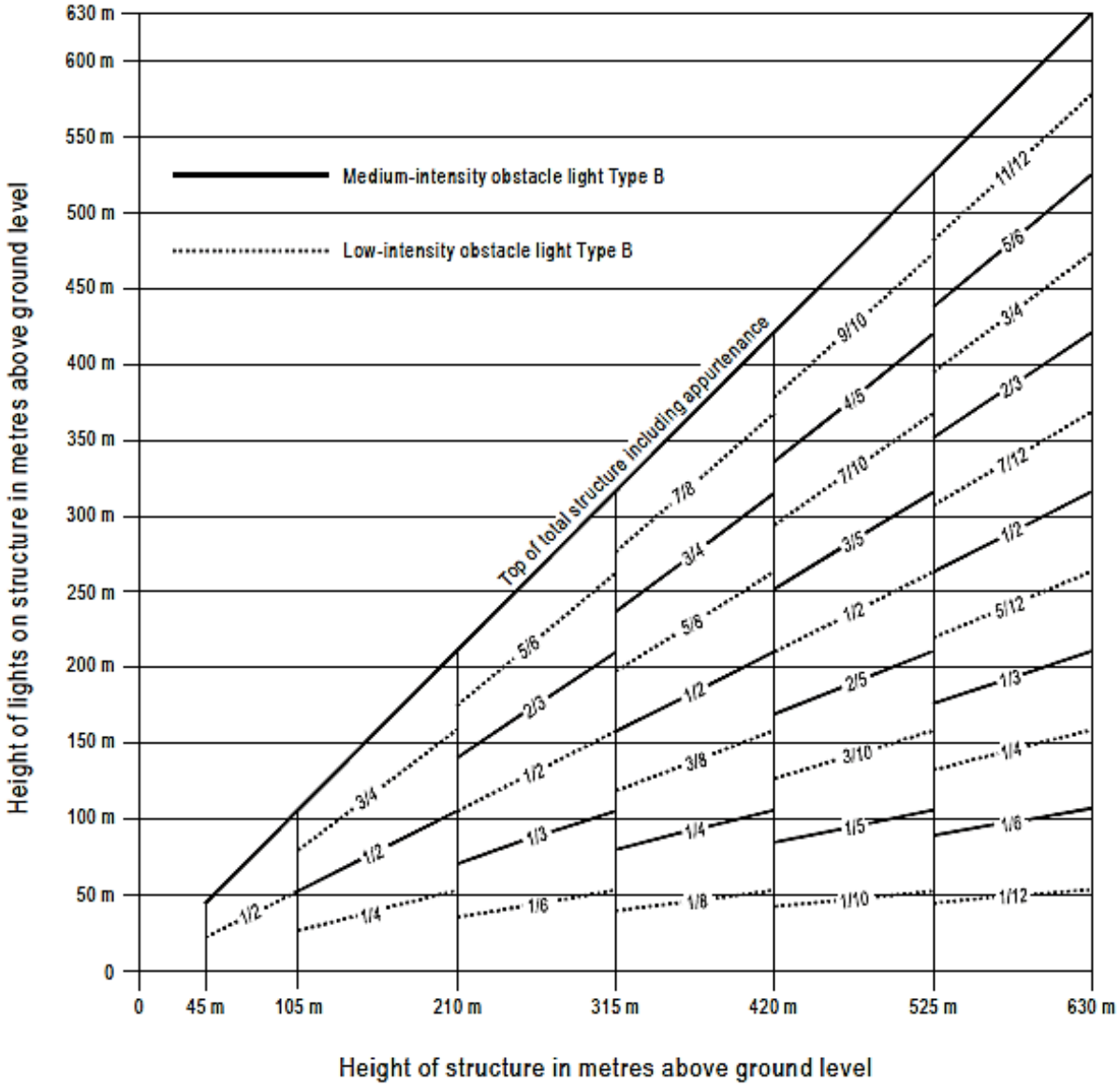
Figure APP.E-1: Medium-intensity flashing-white obstacle lighting system, Type A



Source: ICAO Annex 14 Volume 1

Note: Obstacle lighting with high intensity is recommended for structures with a height greater than 150 metres above the ground. Marking will also be necessary if medium-intensity lighting is employed.

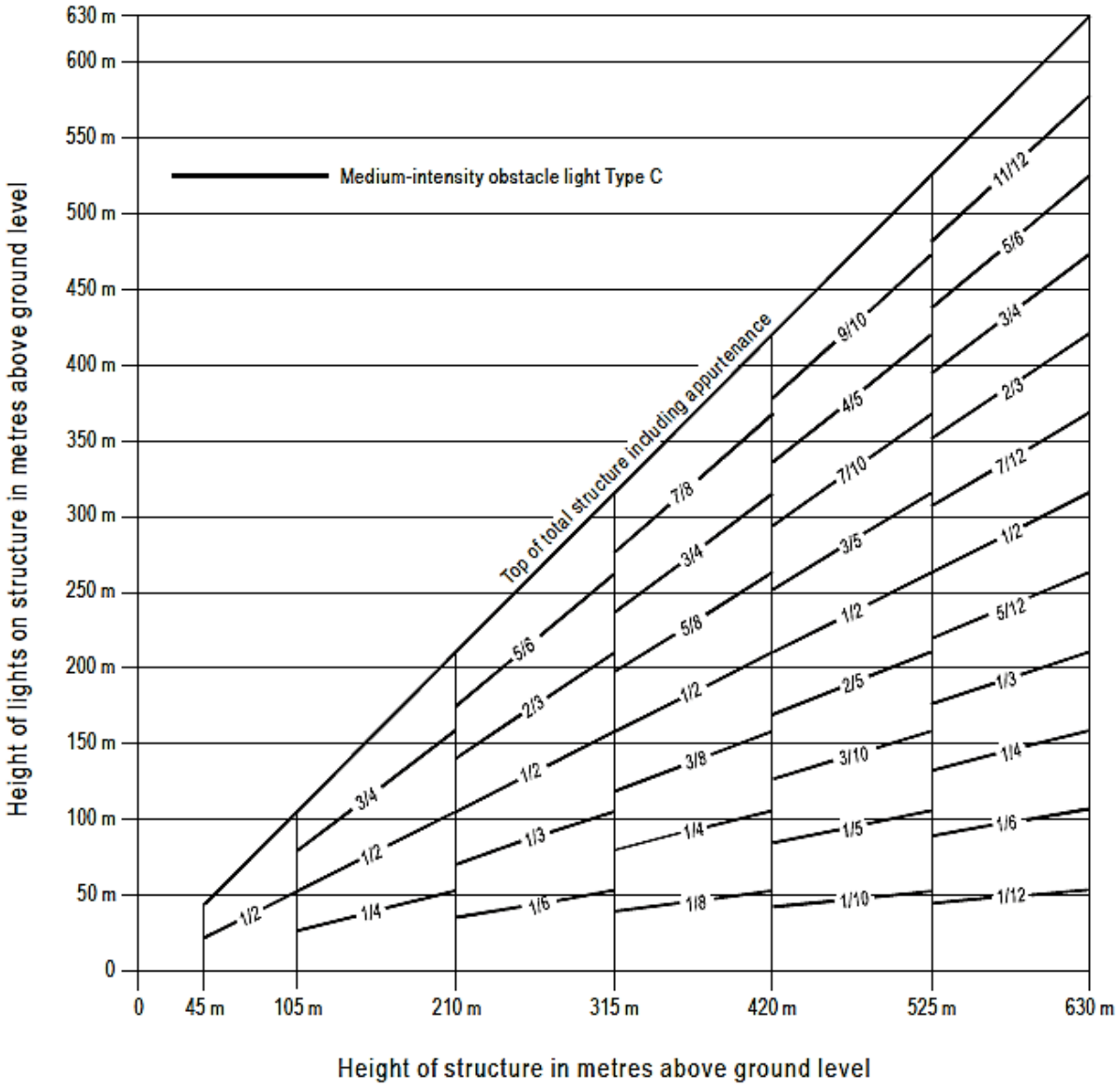
Figure APP.E-2: Medium-intensity flashing-red obstacle lighting system, Type B



Source: ICAO Annex 14 Volume 1

Note: Only for night-time use

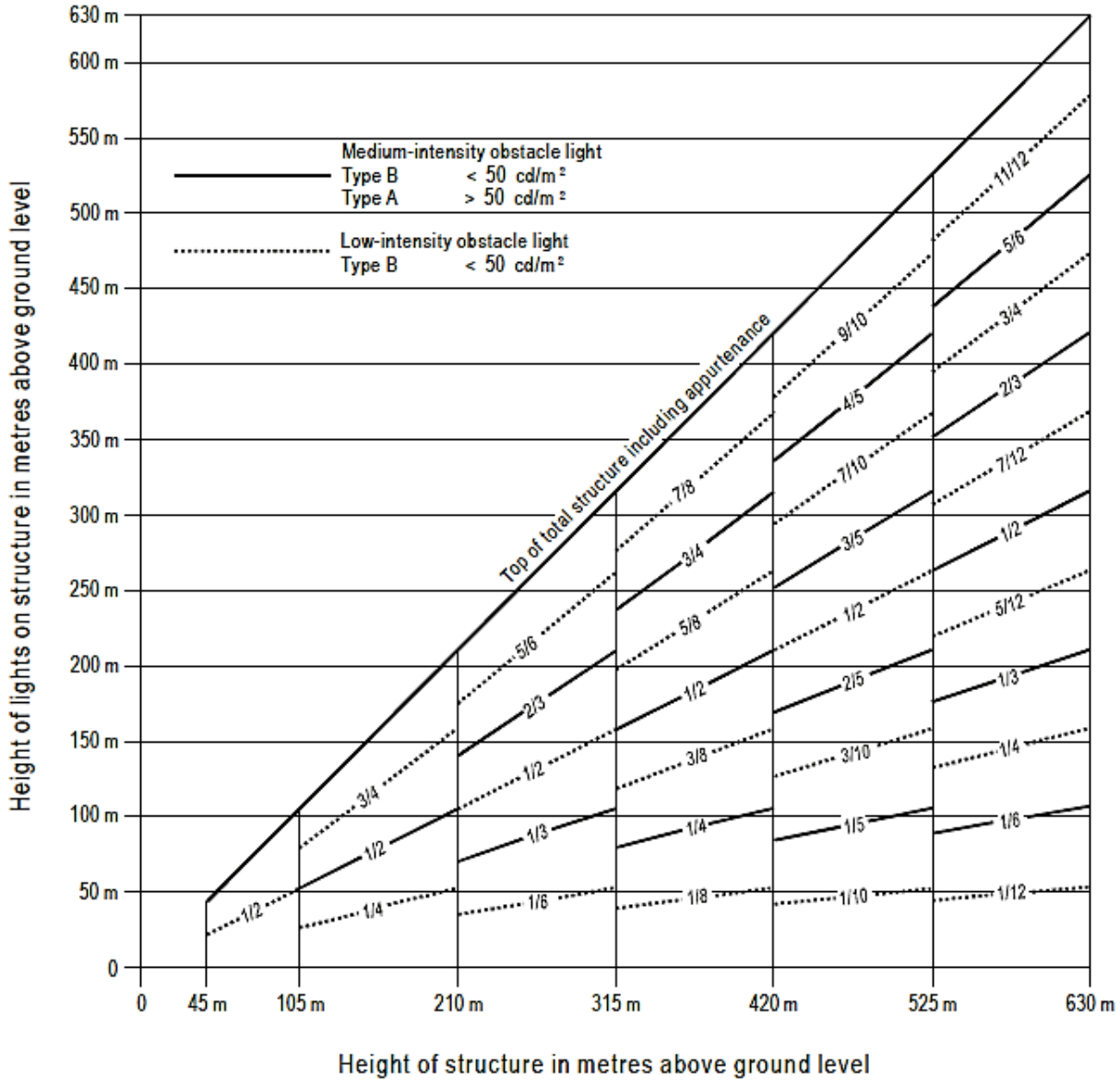
Figure APP.E-3: Medium-intensity fixed-red obstacle lighting system, Type C



Source: ICAO Annex 14 Volume 1

Note: Only for night-time use

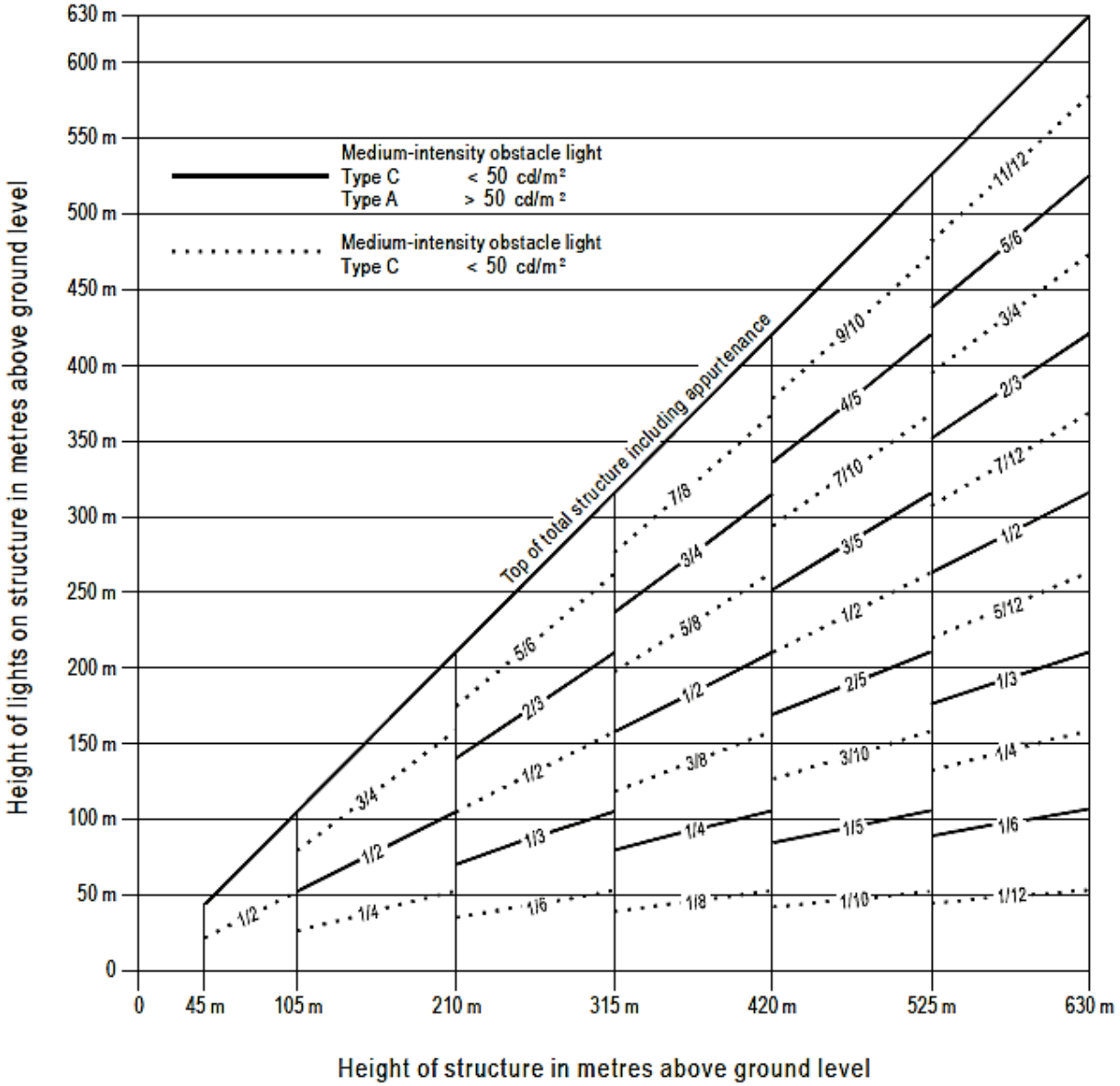
Figure APP.E-4: Medium-intensity dual obstacle lighting system, Type A/Type B



Source: ICAO Annex 14 Volume 1

Note: Obstacle lighting with high intensity is recommended for structures with a height greater than 150 metres above the ground. Marking will also be necessary if medium-intensity lighting is used.

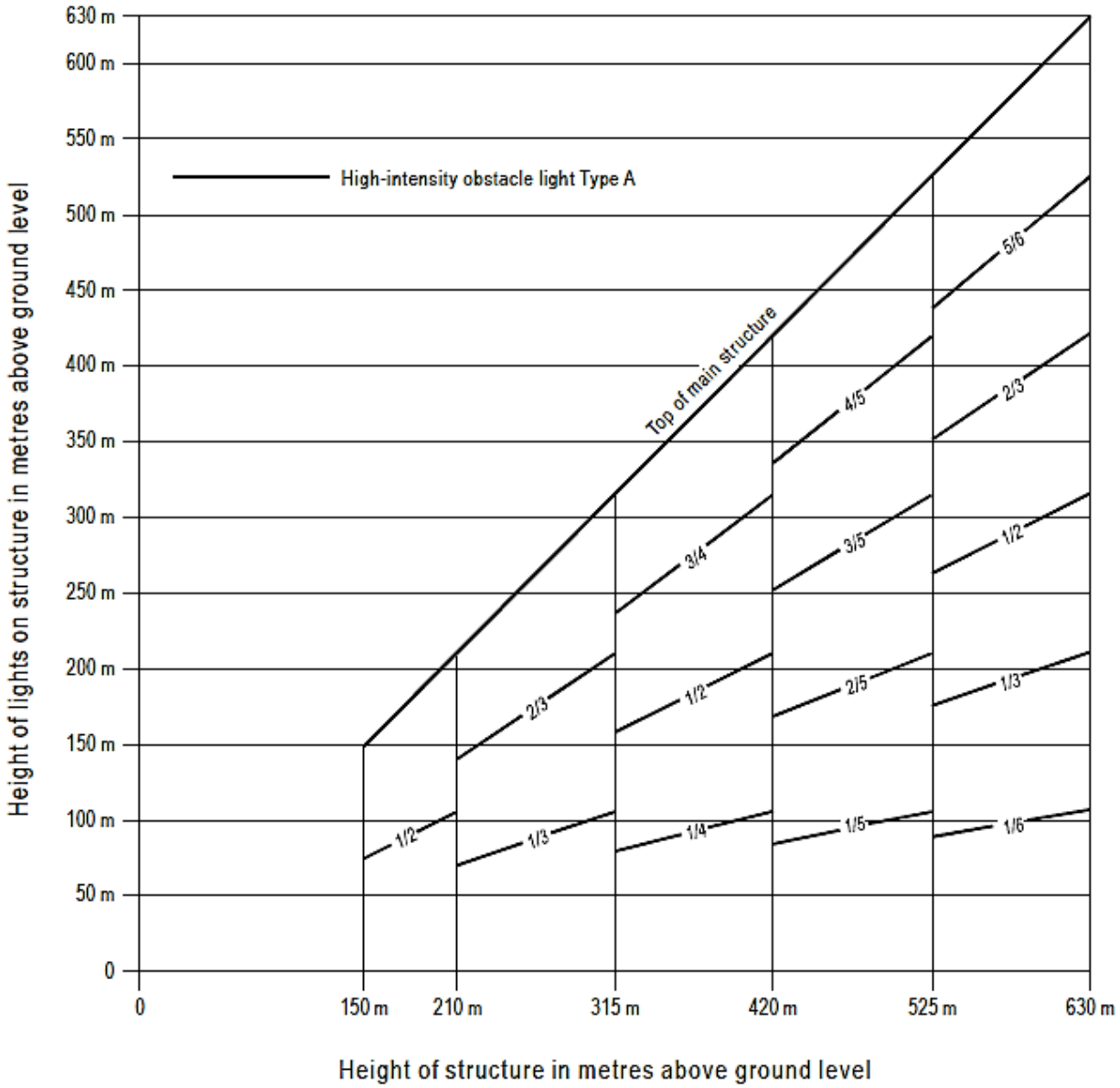
Figure APP.E-5: Medium-intensity dual obstacle lighting system, Type A/Type C



Source: ICAO Annex 14 Volume 1

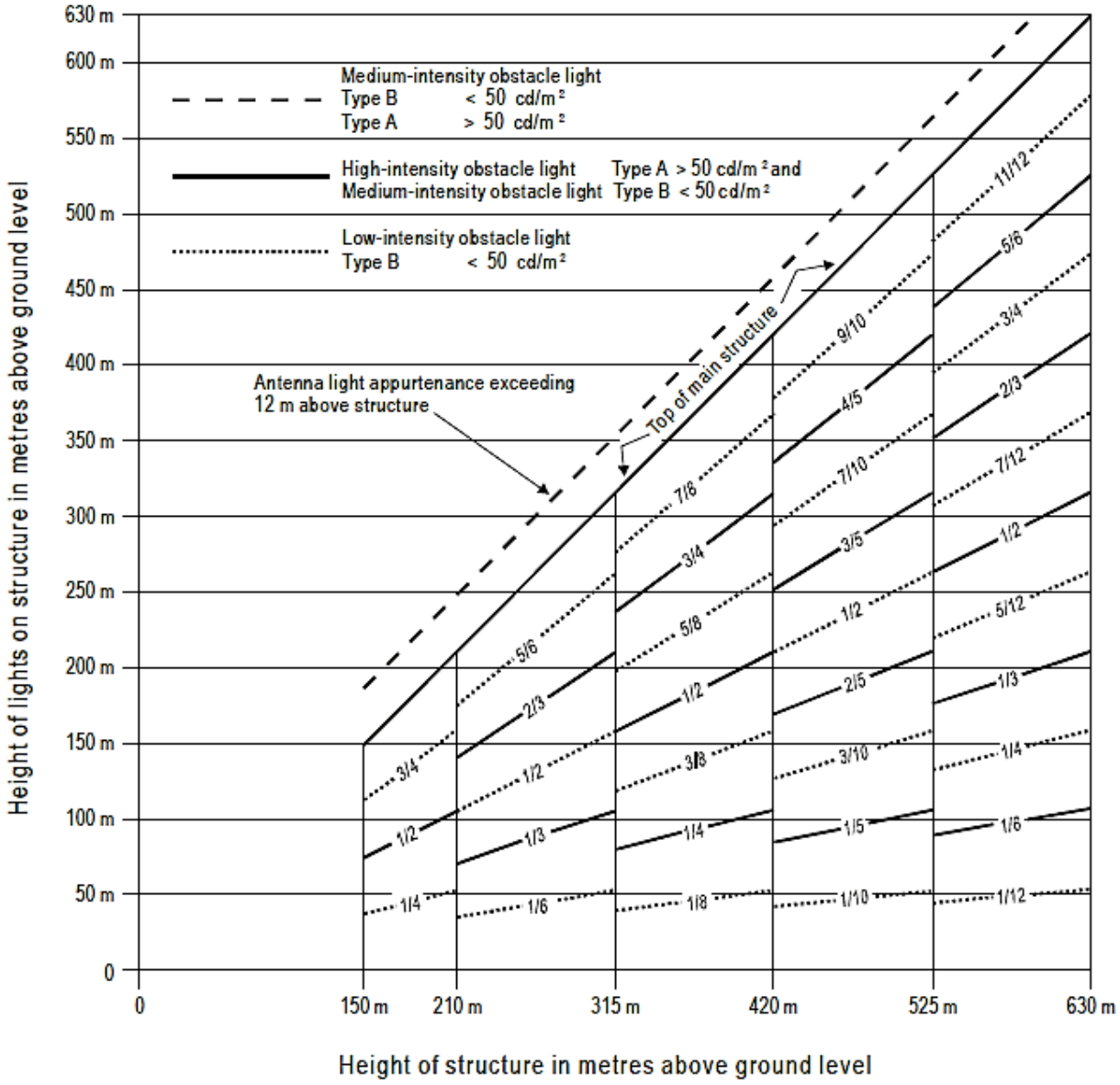
Note: On structures with a height greater than 150 metres above the ground, it is advised to install intense obstacle lighting. Marking will be required if medium-intensity lighting is utilised.

Figure APP.E-6: High-intensity flashing-white obstacle lighting system, Type A



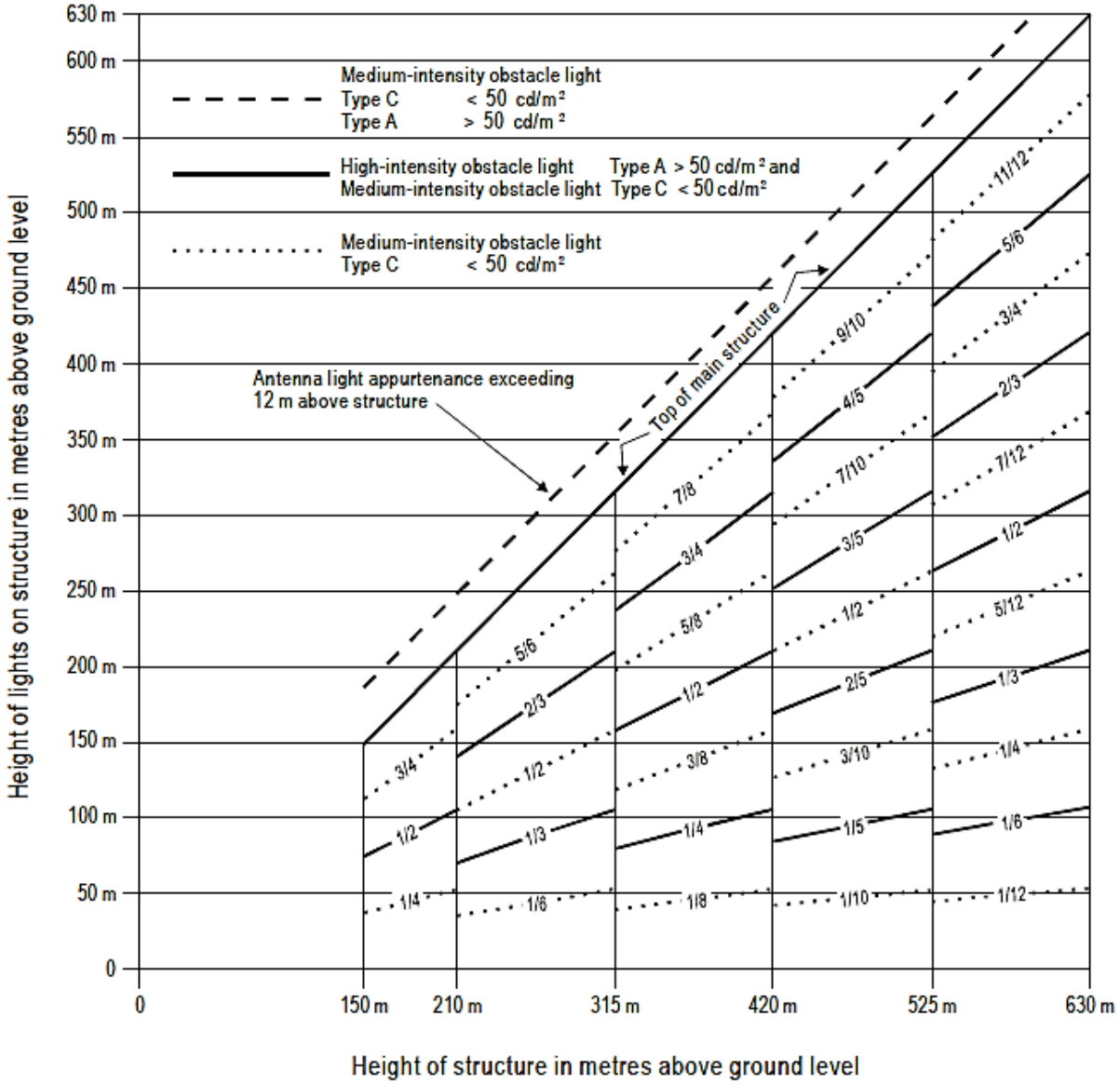
Source: ICAO Annex 14 Volume 1

Figure APP.E-7: High-/medium-intensity dual obstacle lighting system, Type A/Type B



Source: ICAO Annex 14 Volume 1

Figure APP.E-8: High-/medium-intensity dual obstacle lighting system, Type A/Type C

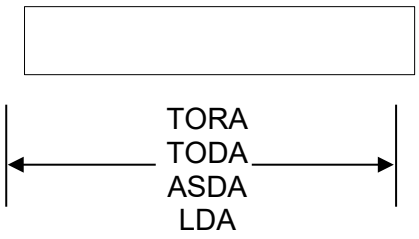


Source: ICAO Annex 14 Volume 1

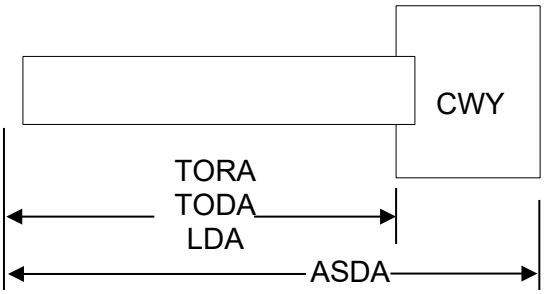
Appendix F – Calculation of declared distances

(a) The declared distances to be calculated for each runway direction are as follows: the take-off run available (TORA), the take-off distance available (TODA), the accelerate-stop distance available (ASDA), and the landing distance available (LDA).

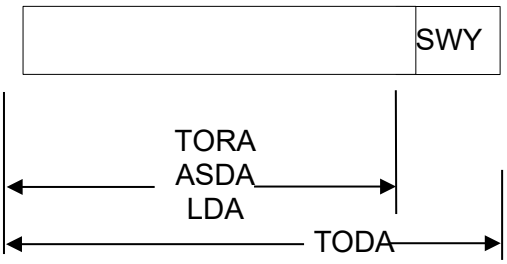
(b) When a runway lacks a stopway or clearway and the threshold is located at the extreme end of the runway, the four declared distances shall normally be equal to the length of the runway, as shown below



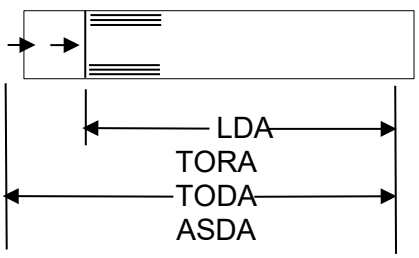
(c) When a runway has a clearway (CWY), the TODA will include the length of the clearway, as shown below.



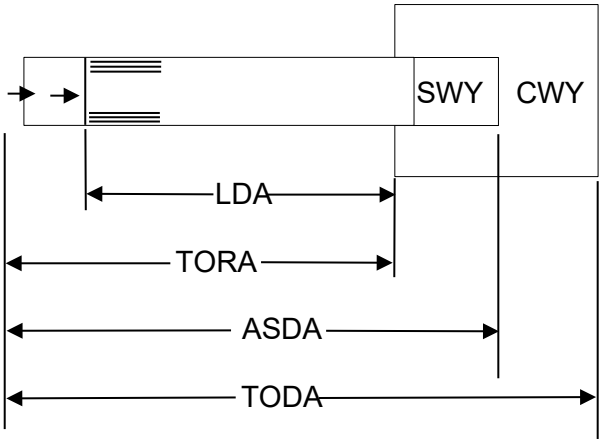
(d) When a runway has a stopway (SWY), the ASDA will include the length of the stopway, as shown below.



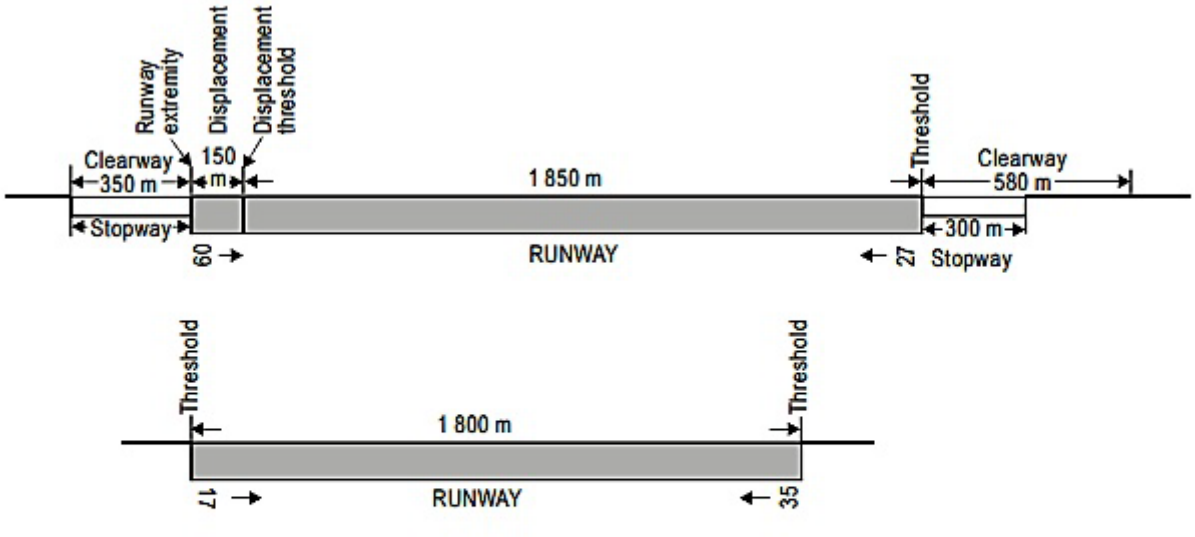
(e) When a threshold of the runway is displaced, the LDA is reduced by the distance the threshold is displaced, as shown below. A displaced threshold only affects the LDA for approaches to that threshold; all declared distances for operations in the opposite direction are unaffected.



(f) The images below depict a runway with a clearway, a stopway, or a displaced threshold. Where more than one of these features exists, more than one of the declared distances will be modified — but the modification will adhere to the same principle as shown. The final diagram below depicts an example of a situation with all these characteristics.



(g) The figure below depicts a suggested format for providing information on declared distances. If a runway direction cannot be used for take-off or landing, or both, due to operational restrictions, it shall be declared, and the words "not usable", or the abbreviation "NU" entered.



RUNWAY	TORA	ASDA	TODA	LDA
	m	m	m	m
09	2 000	2 300	2 580	1 850
27	2 000	2 350	2 350	2 000
17	NU	NU	NU	1 800
35	1 800	1 800	1 800	NU

Source: ICAO Annex 14 Volume 1

Note: All declared distances are illustrated for operations from left to right.

Appendix G – Aerodrome mapping data

The aerodrome mapping data features are collected and made available to aeronautical information services for aerodromes with the intended applications in mind. These applications are closely related to a recognised need and operational use of the data.

(a) Aerodrome geographic information is included in aerodrome mapping data to support applications that enhance situational awareness or add to surface navigation, thereby strengthening safety margins and operational effectiveness. These data sets support applications for common situational awareness, aerodrome guidance, and collaborative decision-making when the data element accuracy is appropriate. These air navigation applications are intended uses for the data sets:

(1) on-board positioning and route awareness, including moving maps with the current position of the aircraft, surface guidance, and navigation;

(2) traffic awareness, including surveillance and alerting for runway incursions (as in, respectively, A-SMGCS levels 1 and 2);

(3) ground positioning, route awareness, situational displays showing the positions and taxi routes of aircraft and vehicles, as well as surface guidance and navigation (such as A-SMGCS levels 3 and 4);

(4) facilitation of NOTAMs and other aeronautical information relevant to aerodromes;

(5) management of resources and aerodrome facilities; and

(6) creation of aeronautical charts.

(b) Other applications for the data include training/flight simulators, on-board or ground enhanced vision systems (EVS), synthetic vision systems (SVS), and combined vision systems (CVS).

(c) The following aerodrome characteristics may be considered when determining which aerodromes may use applications requiring the collection of aerodrome mapping data features:

(1) safety risks at the aerodrome;

(2) visibility conditions;

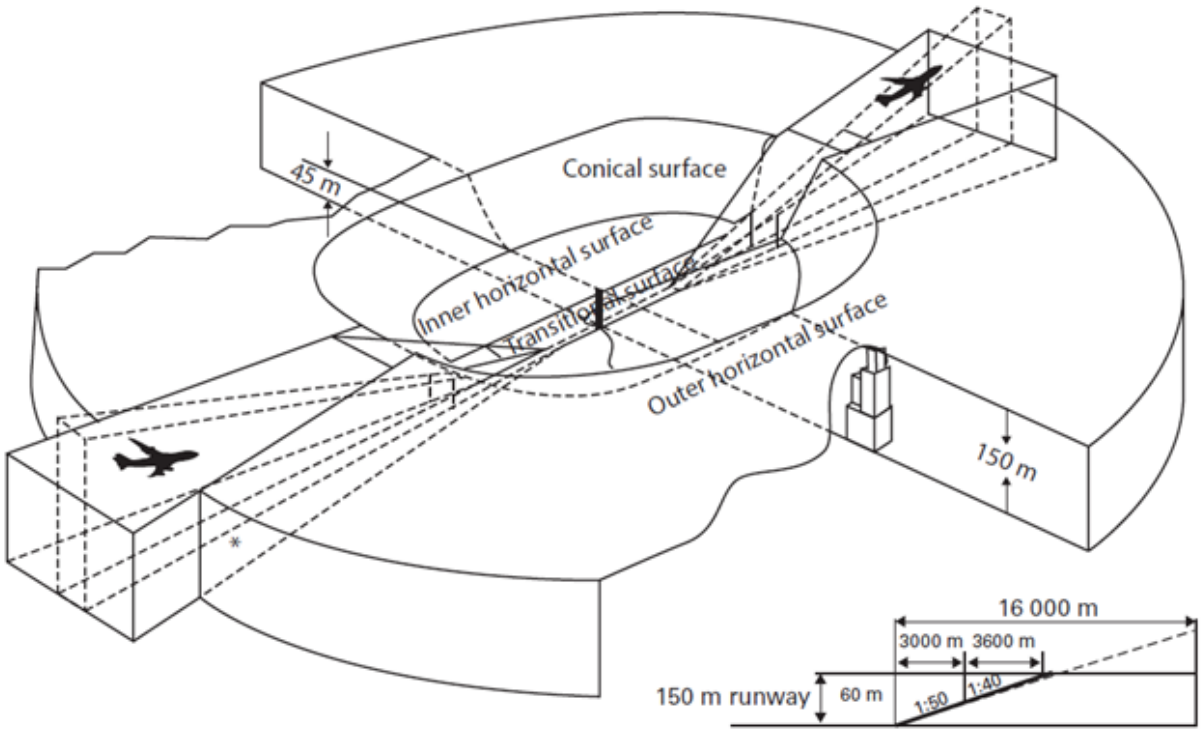
(3) aerodrome layout; and

(4) traffic density.

Note: The Airport Services Manual, Part 8 — Airport Operational Service, contains additional information on aerodrome mapping data (Doc 9137).

Appendix H – Obstacle Limitation Surfaces

Obstacle limitation surfaces for an instrument runway where the main runway is 1800 m or more in length



Longitudinal section through approach and take-off funnels

Note: Both views show the take-off funnels as a chain-dot line. The vertical scale on this chart is 20 times that of the horizontal scale to assess clarity.