CIVIL AVIATION GUIDANCE MATERIAL – 3001

# RUNWAY VISUAL RANGE OBSERVING AND REPORTING

CIVIL AVIATION AUTHORITY OF MALAYSIA

**ISSUE 01**

REVISION 00 – 26TH DECEMBER 2023

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# Introduction

This Civil Aviation Guidance Material 3001 (CAGM – 3001) is issued by the Civil Aviation Authority of Malaysia (CAAM) to provide guidance for Air Traffic Services providers and personnel, pursuant to Civil Aviation Directive 3 – Meteorological Service for International Air Navigation (CAD 3 – MET).

Organisations may use these guidelines to demonstrate compliance with the provisions of the relevant CAD's issued. Without prejudice to Regulation 76, 125 and 126 of the Malaysian Civil Aviation Regulations 2016 (CAR 2016), when the CAGMs issued by the CAAM are used, the related requirements of the CAD's are considered as met, and further demonstration may not be required.

**(DATO' CAPTAIN NORAZMAN BIN MAHMUD)**
Chief Executive Officer
Civil Aviation Authority of Malaysia

## Civil Aviation Guidance Material Components and Editorial Practices

This Civil Aviation Guidance Material is made up of the following components and are defined as follows:

**Standards:** Usually preceded by words such as *"shall"* or *"must"*, are any specification for physical characteristics, configuration, performance, personnel or procedure, where uniform application is necessary for the safety or regularity of air navigation and to which Operators must conform. In the event of impossibility of compliance, notification to the CAAM is compulsory.

**Recommended Practices:** Usually preceded by the words such as "*should"* or "*may*", are any specification for physical characteristics, configuration, performance, personnel or procedure, where the uniform application is desirable in the interest of safety, regularity or efficiency of air navigation, and to which Operators will endeavour to conform.

**Appendices:** Material grouped separately for convenience but forms part of the Standards and Recommended Practices stipulated by the CAAM.

**Definitions:** Terms used in the Standards and Recommended Practices which are not self-explanatory in that they do not have accepted dictionary meanings. A definition does not have an independent status but is an essential part of each Standard and Recommended Practice in which the term is used, since a change in the meaning of the term would affect the specification.

**Tables and Figures:** These add to or illustrate a Standard or Recommended Practice and which are referred to therein, form part of the associated Standard or Recommended Practice and have the same status.

**Notes:** Included in the text, where appropriate, Notes give factual information or references bearing on the Standards or Recommended Practices in question but not constituting part of the Standards or Recommended Practices;

**Attachments:** Material supplementary to the Standards and Recommended Practices or included as a guide to their application.

It is to be noted that some Standards in this Civil Aviation Guidance Material incorporates, by reference, other specifications having the status of Recommended Practices. In such cases, the text of the Recommended Practice becomes part of the Standard.

The units of measurement used in this document are in accordance with the International System of Units (SI) as specified in CAD 5. Where CAD 5 permits the use of non-SI alternative units, these are shown in parentheses following the basic units. Where two sets of units are quoted it must not be assumed that the pairs of values are equal and interchangeable. It may, however, be inferred that an equivalent level of safety is achieved when either set of units is used exclusively.

Any reference to a portion of this document, which is identified by a number and/or title, includes all subdivisions of that portion.

Throughout this Civil Aviation Guidance Material, the use of the male gender should be understood to include male and female persons.

## Record of Revisions

Revisions to this CAGM shall be made by authorised personnel only. After inserting the revision, enter the required data in the revision sheet below. The *'Initials'* has to be signed off by the personnel responsible for the change.

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# Summary of Changes

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# Table of Content

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# 1 Definition, Purpose and Operational Use of RVR

## 1.1 Definition

1.1.1 RVR is defined in CAD 3, Chapter 1, as:
"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."

1.1.2 The definition implies that RVR is not an "observation" or a "measurement" of a meteorological parameter such as surface wind direction and speed, temperature and pressure; it is an assessment, based on calculations that consider various elements, including atmospheric factors such as extinction coefficient of the atmosphere, physical/biological factors such as visual threshold of illumination, and operational factors such as runway light intensity. Therefore, the assessment of RVR presents many more complexities than the mere observation of meteorological parameters and, for this reason, there exists a need for detailed information and guidance on the subject.

## 1.2 Purpose

1.2.1 The main purpose of RVR is to provide pilots, air traffic services (ATS) units and other aeronautical users with information on runway visibility conditions during periods of low visibility, whether due to fog, the most frequent cause of low visibility in many places, or due to other causes such as rain, snow or sandstorms. In particular, RVR is required to assess whether conditions are above or below the specified operating minima for take-off and landing. It is to be noted that for this purpose RVR values supersede the reported visibility and that in the case of precision approaches it is normally not permissible to start an approach if the applicable RVR value(s) is below the required minimum.

1.2.2 The commonly acceptable aerodrome operating minima for different runway categories (defined in CAD 14 — Aerodromes, Volume I — Aerodrome Design and Operations) are specified in the Manual of All-Weather Operations (Doc 9365) (also see 6.5.4). The range of RVR assessments (i.e. from 50 to 2 000 m) is designed to cover most aerodrome operating minima. Therefore, RVR requires a high reporting resolution as indicated in 6.4.

## 1.3 Operational Use

1.3.1 Operationally, RVR is sometimes taken to have a broader meaning than as defined in 1.1.1, in that it is used by many pilots as an indication of the visual guidance that may be expected during the final approach, flare, touchdown and roll-out. In this way, RVR may be assumed by the pilot to provide an indication of the overall visual range conditions. However, as RVR applies only for the visual range on the runway, the conditions during the approach may be significantly different. Until the pilot is actually on the runway, the view from the cockpit down to the ground represents rather a slant visual range (SVR) and as such may be affected by fog densities varying with height. Whilst SVR would be the ideal representation of the visual range, there is currently no requirement for SVR owing to the inherent difficulties in its measurement or assessment and the fact that research into its assessment has been negligible in recent years. Furthermore, it is now widely accepted that the use of RVR has ensured the safe conduct of low-visibility operations over the last few decades.

1.3.2 The fact that RVR depends upon both meteorological and operational parameters complicates the assignment of responsibility for RVR assessments. The responsibility for RVR assessments can be assigned to the meteorological office or to the ATS provider. The determination of assignment shall be decided by both service providers.

# 2 Explanations of Terms

## 2.1 Explanation

2.1.1 These explanations are generally based on established scientific definitions, some of which have been simplified to assist non-specialist readers. Approved ICAO definitions are marked with an asterisk (*) and published WMO definitions with a double asterisk (**). The units, where appropriate, are indicated in brackets.

2.1.2 In considering the definitions below, the following assumptions are made:

a) extinction coefficient, meteorological optical range, transmissivity and transmittance can all be defined in terms of luminous flux and are interchangeable for quantifying the clarity (i.e. transparency) of the atmosphere;

b) for all definitions, luminous flux is defined by the International Commission on Illumination (CIE) response of human vision; and

c) whether stated or not, quantities related to luminous flux are referenced to an incandescent light source with a colour temperature of 2 700 K.

***Extinction coefficient**** ***(σ)*** means the proportion of luminous flux lost by a collimated beam, emitted by an incandescent source at a colour temperature of 2 700 K, while travelling the length of a unit distance in the atmosphere (per metre, m–1).

*Note 1. — The coefficient is a measure of the attenuation due to both absorption and scattering.*

*Note 2. — Using the assumptions in 3.2, the definition can be also stated as follows: the proportion of luminous flux lost by a collimated beam while travelling the length of a unit distance in the atmosphere.*

***Illuminance**** ***(E)*** means the luminous flux per unit area (lux, lx).

*Note. — The radiant flux represents the power in a light beam while the luminous flux represents the magnitude of the response of the human eye to the light beam.*

***Meteorological optical range (MOR)**** means the length of the path in the atmosphere required to reduce the luminous flux in a collimated beam from an incandescent lamp, at a colour temperature of 2 700 K, to 0.05 of its original value, the luminous flux being evaluated by means of the photometric luminosity function of the International Commission on Illumination (CIE) (metre (m) or kilometre (km)).

*Note 1.— The relationship between meteorological optical range and extinction coefficient (at the contrast threshold of □ = 0.05) using Koschmieder's law is: MOR = –ln (0.05)/σ ≈3/σ. MOR = visibility under certain conditions (see below).*

*Note 2. — Using the assumptions in 3.2, the definition can be also stated as follows: the length of the path in the atmosphere required to reduce the luminous flux in a collimated beam to 0.05 of its original value.*

***Runway visual range (RVR)**** means 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 (metre, m).

***Scatter meter*** is an instrument for estimating extinction coefficient by measuring the flux scattered from a light beam by particles present in the atmosphere.

***Slant visual range (SVR)*** means the visual range of a specified object or light along a line of sight which differs significantly from the horizontal; for example, the visual range of ground objects or lights as seen from an aircraft on the approach (metre, m).

***Transmissometer*** is an instrument that takes a direct measurement of the transmittance between two points in space, i.e. over a specified path length or baseline.

***Visibility (V)*.*** Visibility for aeronautical purposes is the greater of:

a) the greatest distance at which a black object of suitable dimensions, situated near the ground, can be seen and recognized when observed against a bright background;
b) the greatest distance at which lights in the vicinity of 1 000 candelas can be seen and identified against an unlit background.

*Note. — The two distances have different values in the air of a given extinction coefficient, and the latter b) varies with the background illumination. The former a) is represented by the meteorological optical range (MOR).*

***Visual range*** means the maximum distance, usually horizontally, at which a given light source or object is just visible under particular conditions of background luminance.

# 3 Weather Phenomena Reducing Visibility

## 3.1 Introduction

3.1.1 Visibility is always restricted to some extent by the effect of light being scattered and absorbed by atmospheric particles (e.g. microscopic salt crystals, dust and soot particles, water droplets), whether suspended in or falling through the atmosphere. Even in the absence of particles, molecular scattering (Rayleigh scattering) limits visibility. Hence, infinite visibility never occurs in the atmosphere, although it is often possible to see over long distances. This chapter reviews the weather phenomena that can reduce visibility, with particular emphasis on those that can reduce the visibility into the RVR range, i.e. below 1 500 m. Table 3-1 lists the most common of those weather phenomena and some of their characteristics. The MOR ranges indicated are typical values based on experience. The issue of absorption is relevant to scatter meters only while the wavelength dependence is applicable for any instrument with the optical response not centred around 0.55µm (i.e. maximum response for human vision).

3.1.2 Mist and fog are, in many parts of the world, the primary causes for visibility restrictions of operational significance. Heavy precipitation may also cause low visibility restricting aircraft operations.

| Weather phenomenon | Typical MOR values (m) | Absorbing | Wavelength dependent |
|---|---|---|---|
| Sandstorm | - | Yes | Possible |
| Dust storm | - | Yes | Possible |
| Smoke | - | Possible | Possible |
| Haze | 1 000 – 5 000 | Possible | Yes |
| Mist | 1 000 – 5 000 | No | No |
| Fog | 30 – 1 000 | No | No |
| Drizzle | > 1 000 | No | No |
| Rain | > 1 000 | No | No |
| Snow | > 300 | No | No |
| Blowing snow | > 50 | No | No |

Table 3-1: Common weather phenomena reducing visibility

## 3.2 Lithometeors: Haze, Sand, Dust, Smoke and Volcanic Ash

3.2.1 The reduced visual range due to dust or other microscopic (dry) particles in the atmosphere is called haze. In the haze, blue light is scattered more than red light such that dark objects are seen as if viewed through a veil of pale blue. Visibility is not necessarily constant in any direction because variations due to smoke and other impurities from residential and industrial areas often occur. Haze and other lithometeors are reported only when the visibility is 5 000 m or less (except for low drifting sand and volcanic ash which are always reported for operational reasons).

3.2.2 The small-particle lithometeors (haze, smoke and volcanic ash) can remain suspended more or less indefinitely in the atmosphere. Only under abnormal conditions, such as dense smoke from large fires, will these phenomena reduce the visibility below 1 500 m.

3.3 Hydrometeors: Mist and Fog

3.3.1 Mist is an atmospheric obscuration produced by suspended microscopic water droplets or wet hygroscopic particles, generally producing a thin greyish veil over the landscape. The particles contained in a mist have diameters mainly of the order of a few tens of micrometres.

3.3.2 Mist is reported when the visibility is at least 1 000 m but not more than 5 000 m with a relative humidity greater than 90 per cent.

3.3.3 Fog is an atmospheric obscuration in the lowest layers of the atmosphere which is caused by a concentrated suspension of water droplets or ice crystals, the air being at about 100 per cent humidity. In cold conditions, the suspension may be ice crystals and the resulting fog is called ice fog.

3.3.4 Fog is generally classified according to the physical process that produces the saturation or near saturation of the air. Radiation fog forms as a result of radiative cooling, usually on cloudless nights in light wind conditions. Advection fog forms as warm, moist air from the sea or land cool as it passes over a colder surface. Sea fog is an advection fog that forms as warm air from the land moves out over cooler water. Evaporation fog (steam fog) is produced within a colder and stable air mass by rapid evaporation from an underlying warmer water surface. Upslope fog forms as the air cool when it is blown up a slope causing mountain obscuration. Clouds form by the same processes, and when stratus clouds descend to the ground they are considered to be fog.

3.3.5 Fog is reported when the visibility is less than 1 000 m.

3.3.6 During the life of a fog its characteristics and the visual conditions within it change (see also 6.5.2). For purposes of description it can be said that most fogs have three phases:

a) fog onset phase

This is the time from the first signs of fog until it has become continuous over a relatively large area. In the case of advection fog blown onto and across the aerodrome, this phase may last only a few minutes. At the other extreme, radiation fog may take up to several hours to complete this phase, but it can also form very quickly. Radiation fog may first appear as very shallow but dense patches of ground fog. Later, large isolated patches may form and drift slowly along in very light wind. At night, the existence of such patches is not evident until one of them encounters an instrument and results in a low value of RVR. Alternatively, shallow ground fog may form, covering part or the whole of the aerodrome. As a result, during the fog onset period, especially in radiation fog, large local spatial and temporal variations in visibility may exist and the RVR reported from individual instruments may not be representative of the whole runway.

b) main fog phase

This applies to any type of fog which has formed as a continuous blanket over a relatively large area including part or all of the aerodrome, until it starts to decay or disperse. Such fog can be spatially uniform, with relatively small and slow changes in visibility. However, in other instances, changes in visibility of up to about 50 per cent can occur within the main body of the fog. Generally, the visibility conditions are fairly well represented by observations and instrumented measurements. Since changes are gradual, trends can be easily discerned.

c) decay phase

This covers the decay or dispersal period of the fog. Large changes in visibility within the fog can occur, but the variations can also remain small. Instrumented measurements are normally fairly representative except when radiation fog starts to lift off the ground to become low stratus.

## 3.4 Precipitation

3.4.1 Precipitation is a hydrometeor consisting of water particles, liquid or solid, that fall from the atmosphere and reach the ground. Precipitation includes drizzle, rain, snow, snow grains, ice crystals (diamond dust), ice pellets, hail, small hail and/or snow pellets.

3.4.2 Precipitation can be characterized by its droplet size and physical state as follows:

a) Drizzle

Fairly uniform precipitation composed exclusively of fine drops of water with diameters from 0.2 to 0.5 mm. The drops appear to float to the ground and are very close to each other. Drizzle usually falls from low stratus and stratocumulus clouds.

b) Rain

Precipitation in the form of liquid water drops, varying in size from 0.5 to a maximum of 6 mm in diameter (generally, drops above 6-mm diameter will break up). Rain may be either continuous or occur as showers.

c) Hail

Precipitation of ice particles (hailstones) with a diameter generally between 5 and 50 mm, hard and partly transparent, that fall separately or frozen together into irregular lumps. Hail falls from cumulonimbus clouds and occurs as showers.

3.4.3 Showers are associated with convective clouds. They are characterized by their abrupt beginning and end and by the generally rapid and great variations in the intensity of the precipitation. Drops and solid particles falling in a shower are generally larger than those falling in non-showery precipitation.

## 3.5 Impact of Weather Phenomena on Visibility

3.5.1 Liquid precipitation (rain, drizzle) alone rarely reduces visibility into the RVR range. However, conditions of liquid precipitation can produce operationally significant values of RVR when the precipitation is accompanied by fog, which is frequently the case with drizzle, or when the precipitation is particularly heavy. In addition, steam fog generated from cooler, moist air moving over a hot, wet runway may also reduce the visibility into the RVR range.

# 4 Observing Practices

## 4.1 Summary of Observing Techniques

4.1.1 Two main observing techniques currently in use are described below. In this context, observing implies instrumented measurements or visual observations of physical parameters (e.g. transmittance, extinction coefficient, number of runway edge lights visible, etc.) on which an assessment of RVR can be based.

a) Instrumented technique

In the determination of RVR by instrumented means it is common practice to use a transmissometer to measure the transmittance of the atmosphere or a forward-scatter meter to measure the atmospheric extinction coefficient. RVR is then calculated considering the measured quantity (i.e. transmittance or extinction coefficient), the characteristics of the lights and the expected detection sensitivity of the pilot's eye under the prevailing conditions of background luminance. There are other instrumented techniques, but at present only those based on transmissometers and forward-scatter meters are recommended for use in assessing RVR.

*Note. – Refer ICAO Doc 9328 Chapter 7 for transmissometer, and Chapter 8 for forward-scatter meter.*

b) Human observer technique

An observer counts the number of runway lights or markers visible from an observing position near the runway. This number is converted to runway visual range, making due allowance for the differences in light intensity, background, etc., from the different viewing positions of the observer and the pilot. Sometimes, where it is difficult to count runway lights, observations are made on a special row of runway or other lights set up near the runway. (Reporting by human observer is considered in Chapter 5.)

4.1.2 In order to meet requirements for the rapid updating of information on changes in RVR, the trend has been towards automatic systems capable of giving digital read-outs of RVR, sometimes supplemented by printed or magnetic records.

4.1.3 Human assessments are not practicable nor recommended for precision approach runways and, in particular, not for those with Categories II and III operations for the following reasons:

a) accuracy and consistency are poorer than those of instrumented RVR systems (4.7.2 refers);

b) multiple locations along the runway must be monitored simultaneously (4.5.4 refers);

c) updating frequency and averaging period as required cannot be adhered to (Section 6.5 refers); and

d) fluctuations of RVR, including tendencies, cannot be indicated (Section 6.6 refers).

4.1.4 The use of instrumented RVR systems is mandatory for Categories II and III operations and is recommended for Category I instrument approach and landing operations. (CAD 3, Appendix 3, 4.3.2.1 and 4.3.2.2 refer.)

## 4.2 Assessments Required

4.2.1 The assessment and reporting of RVR is covered by CAD 3, Chapter 4, 4.6.3, and Appendix 3, 4.3.

4.2.2 According to CAD 3, Chapter 4, 4.6.3.1, RVR must be assessed on all runways intended for Categories II and III instrument approach and landing operations.

4.2.3 Additionally, CAD 3, Chapter 4, 4.6.3.2, states that RVR should be assessed on all runways intended for use during periods of reduced visibility, including:

a) precision approach runways intended for Category I instrument approach and landing operations; and

b) runways used for take-off and having high-intensity edge lights and/or centre line lights.

*Note. — Precision approach runways are defined in CAD 14, Volume I, Chapter 1, under "Instrument runway".*

4.2.4 Where RVR assessments are required, according to CAD 3, Chapter 4, 4.6.3.3, they should be made and reported throughout periods when either the visibility or the RVR is observed to be less than 1 500 m.

4.2.5 RVR can be reported for values ranging from 50 m to 2 000 m (CAD 3, Appendix 3, 4.3.6.2 refers). It should be noted that values in the range 1 500 m to 2 000 m would only be reported in situations where the visibility is less than 1 500 m.

## 4.3 Locations for Assessments — General

4.3.1 RVR systems should be set up to provide assessments that are representative of a pilot's viewing position to the extent possible without infringing on the obstacle provisions of CAD 14 — Aerodromes, Volume I — Aerodrome Design and Operations; and, in case of human observers, without risk to the observers. These provisions require that objects which, because of their functions, are permitted within the strip1 in order to meet air navigation requirements, should be frangible and sited in such a manner as to reduce collision hazards to a minimum (CAD 14, Volume I, 9.9).

4.3.2 Since the RVR cannot be measured directly on the runway, the error caused by the difference in conditions at the runway and at the location where the RVR is assessed can have an operational impact. The RVR systems are usually installed up to 120 m from the runway centre line on a grass or sand surface. In contrast, the runway is made of concrete or asphalt, which may warm more rapidly than the surrounding grass or sand surfaces. The resulting temperature difference between the runway and surrounding area will affect the distribution of fog and may result in a greater RVR along the runway than that assessed by the instruments. This effect may be enhanced by aircraft movements on the runway. At least in the short term, aircraft movements on the runway tend to cause the dissipation of fog due to the hot exhaust gases and turbulence generated. However, the exhaust gases contain condensation nuclei and water vapour which may lead to the thickening of fog in a longer term.

*Note. — The "strip" of a precision approach runway or an instrument approach runway should extend to a distance of at least 150 m on each side of the centre line of the runway and its extended centre line throughout the length of the strip (CAD 14, Volume I, 3.4.3 and 3.4.4).*

## 4.4 Height Above Runway

4.4.1 An eye level of 5 m above the runway was originally suggested as being representative of a pilot's viewing position above the runway. Since the runway lights are near ground level, this implied an average height of about 2.5 m for the light path to a pilot's eyes. It is therefore recommended that RVR should be assessed at a height of approximately 2.5 m (7.5 ft) (CAD 3, Appendix 3, 4.3.1.1, refers).

4.4.2 For the human observer system, the observer's eye height should, ideally, be 5 m, the same as that of the representative viewing position of the average pilot. In practice, the observer often stands on the ground. At some aerodromes, it is impossible to see and identify all the required lights from such a low level because of humps and dips in the runways or snow banks alongside the runways. In these cases, assessments should be made from an elevated platform or the top of a vehicle. Also, raised positions are sometimes necessary in order to obtain a better view of the lights on the far side of the runway where these are used for RVR assessments.

4.4.3 In practice, the pilot's eye height can vary significantly from the 5-m value assumed in paragraph 4.4.1. Figure 4-1 illustrates this variation for commercial aircraft registered in the United States; similar variations would be expected for aircraft in other States. The figure presents the cumulative percentage of windscreen heights. Each point represents the contribution of a particular aircraft type. The height distribution is dominated by the large percentage of narrow-body commercial jet transport aircraft that appear as three large vertical steps in the cumulative percentage at heights between 3 and 4 m. The large horizontal step at the top of the figure is the contribution of the Boeing-747 which has the highest cockpit window. The median height (corresponding to 50 per cent of aircraft) is about 3.6 m. The height of 5 m assumed in 4.4.1 is at the 89th percentile. Although the pilot's eye height can be almost a factor of two higher or a factor of three lower, than the 5-m value, it would be impractical to vary the measurement height from one airport to the next based on the typical pilot eye height at the airport.

4.4.4 Despite these differences in eye height of aircraft on the runway, the light intensities directed towards the pilot from runway edge and centre line lights conforming to ICAO specifications do not vary to a significant extent. Hence RVR is not very sensitive to the changes in eye height presented by various aircraft, as far as runway light intensity is concerned.

4.4.5 However, if the reduction in visibility varies with distance from the ground, the effective RVR value can depend upon eye height. Consideration should also be given to the possible influence of vegetation, snow banks, etc., in that they may:

a) reduce fog density near the ground and thereby enhance the variation in RVR with eye height; and

b) shield the instrument and prevent a representative measurement.

In general, vegetation and snow banks in the vicinity of runways and RVR sensors should be kept well below the lowest pilot eye height and the height of the instrumented measurement.

## 4.5 Position Along the Runway

4.5.1 Since visibility is often not uniform (e.g. patchy fog), the ideal would be for the observations to cover the entire length of the runway. This is, however, impracticable as such coverage would require the installation of an excessive number of instruments. It is, therefore, usual to make the observations near the touchdown zone and at selected additional sites to provide satisfactory indications of conditions in the parts of the runway of primary interest, normally the mid-point and stop-end. This may, of course, sometimes lead to contradictory results, particularly in the case of patchy fog where, for example, one instrument near the touchdown zone could give an RVR of 2 000 m, while a second instrument near the mid-point of the runway, some 1 500 m from the touchdown-zone instrument, could indicate an RVR of 500 m.

4.5.2 CAD 3, Chapter 4, 4.6.3.4, calls for RVR assessments to be representative of the touchdown zone and of the mid-point and stop-end of the runway. The site for observations to be representative of the touchdown zone should be located about 300 m along the runway from the threshold. The site for observations to be representative of the mid-point and stop-end of the runway should be located at a distance of 1 000 to 1 500 m along the runway from the threshold and at a distance of about 300 m from the other end of the runway. The exact position of these sites and, if necessary, additional sites should be decided after considering aeronautical, meteorological and climatological factors such as long runways, location of navigation aids, adjacent structures or the location of swamps and other fog-prone areas.

4.5.3 Existing installations follow these provisions closely. All have one observation site adjacent to the touchdown zone — usually 300 m from the threshold — and many instrumented RVR systems have supplementary observation sites. One of these is usually near the stop-end, which becomes the touchdown zone when the runway is used in the opposite direction.

4.5.4 All-weather operations require the provision of RVR, and the level of detail to be provided depends on the category of aerodrome operations. The detailed requirements for all-weather operations are given in regional air navigation plans as follows:

a) non-precision approach and Category I operations – one site providing information representative of the touchdown zone;

b) Category II operations – as for Category I, plus a second site representative of the mid-point of the runway;

c) Category III operations – as for Category II, but normally with a third position representative of the stop-end of the runway, unless assessments at two sites are adequate for the operations planned.

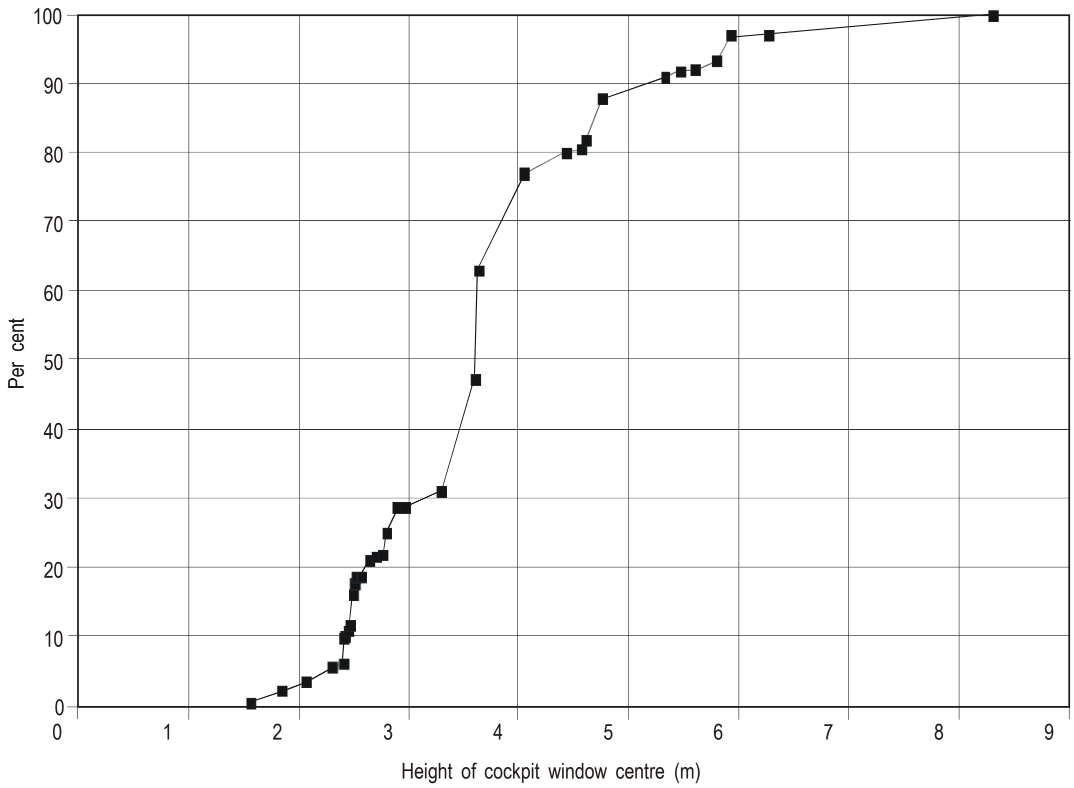



Figure 4-1: Cumulative distribution of cockpit window heights for commercial aircraft

4.5.5 Because visibility can vary considerably along a runway, particularly when fog is forming, useful information can be obtained from multiple instruments even if only Category I operations are being undertaken.

## 4.6 Distance from The Runway

4.6.1 The point from which RVR assessment is made should be such as to present a minimum of hazard to aircraft and instruments and to observers who should never be exposed to the risk of being hit by aircraft taking off or landing. On the other hand, in order that the observations may be closely representative of conditions over the runway, observation sites should be near the runway. This point is recognized in CAD 3, Appendix 3, 4.3.1.2, which indicates that RVR assessments should be carried out at a lateral distance from the runway centre line of not more than 120 m.

4.6.2 Regulatory provisions concerning the construction and siting of equipment and installations are included in CAD 14, Volume I, 9.9, and additional relevant guidance material appears in the Airport Services Manual, Part 6 — Control of Obstacles (Doc 9137). Figure 4-2 indicates the closest positions to the runway at which various meteorological instruments may be located without infringing the transitional surfaces.

4.6.3 With regard to the safety of observers, it should be noted that CAD 14 obstacle limitation specifications relating to the runway strip and associated transitional surfaces effectively prevent the location and use of vehicles or other non-frangible RVR assessment structures (whether fixed or mobile) within the runway strip at any time when the air traffic control (ATC) has cleared aircraft to land or take off (see also 5.2.1).

## 4.7 Accuracy of The Assessments

4.7.1 The accuracy should be compatible with the requirements to report RVR in given increments. The current recommendations for reporting increments are stated in CAD 3, Appendix 3, 4.3.6.1. These are discussed in detail in Section 6.4 of this document.

4.7.2 It was noted that observations made without the aid of instruments were less accurate than those made with instruments. The gap between the accuracies of these two types of assessments of RVR has continued to widen, and only RVR values determined by instruments are likely to approach the accuracies as indicated under “Operationally desirable accuracies” in CAD 3, Attachment A.

## 4.8 Runway Lights to Be Used

4.8.1 When landing in poor visibility conditions (Category I and Category II), the pilot generally needs to see a number of approach and runway lights or markings at and below the decision height. A similar requirement exists for monitoring purposes at heights below 30 m (100 ft) in Category III operations (see the Aerodrome Design Manual, Part 4 — Visual Aids (Doc 9157)). Finally, when landed (and with nose wheel lowered), the pilot sees the runway lights or markings from the cockpit height. A typical approach and runway lighting configuration at the inner 300 m for Categories II and III is presented in Figure 4-3.

4.8.2 It is highly desirable that the RVR assessments be based on the lights from which pilots derive their main guidance. Where there are both edge lights and centre line lights, it is normal to use edge lights when RVR assessment is above 550 m; with lower visual range. The tendency is to use centre line lights for the lowest RVR values because of:

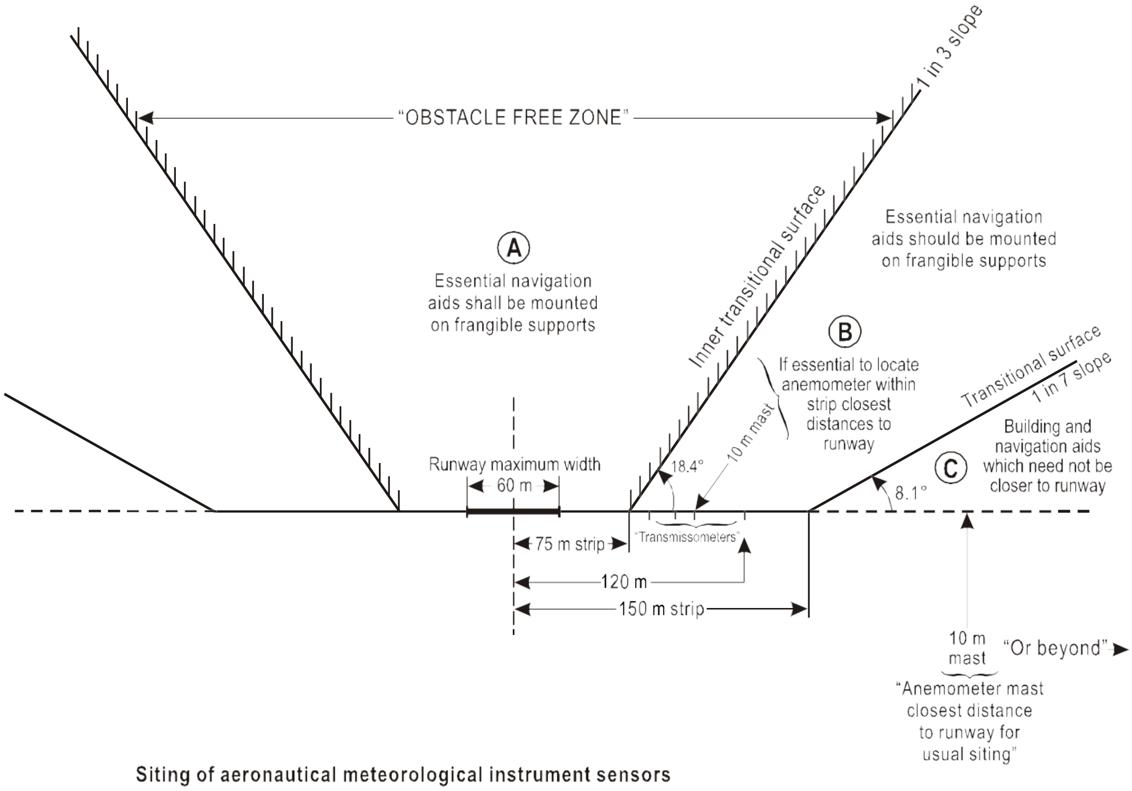
a) the inferior directional guidance provided by edge lights at short range; and

b) the fact that edge lights become dimmer than centre line lights when viewed off axis.

The increasing importance of the guidance provided by the centre line lights as visibility decreases is readily seen if Figure 4-4 is obscured progressively from the top by a sheet of paper having its bottom edge parallel to the longer edges of the diagram. Some States use closer edge light spacing (30 m) than shown in Figure 4-4 and hence may have better guidance from edge lights at low RVR values.

4.8.3 It should be noted that this transition from edge lights to centre line lights as RVR decreases is normally not relevant for human observers. Human observers are generally appropriate only for Category I runways which may not have centre line lights.

*Note. — The operationally desirable accuracy is not intended as an operational requirement; it is to be understood as a goal that has been expressed by the operators.*




**Siting of aeronautical meteorological instrument sensors**

Ⓐ "OBSTACLE FREE ZONE" — Generally speaking no MET sensors should infringe this region unless exceptional local circumstances so dictate. In the latter case sensor supports must be frangible, lighted and if possible sensor should be "shielded" by an existing obstacle.

Ⓑ 1) Transmissometer sited between 66 m and 120 m from runway centre line 2) Ceilometer may be sited in this region if not located near middle marker 3) If essential to locate within strip, anemometer height 10 m minimum distance from centre line = 90 m.

Ⓒ Usual location of anemometer masts minimum distance from runway centre line for 6 m mast is = 192 m and for a 10 m mast = 220 m, assuming surface wind observations made in this region are representative of conditions over runway.

(Cross section of typical precision approach runway reference number 3 or 4)

*Note.— Slope angles not drawn to scale.*

Figure 4-2: Obstacle limitation surfaces

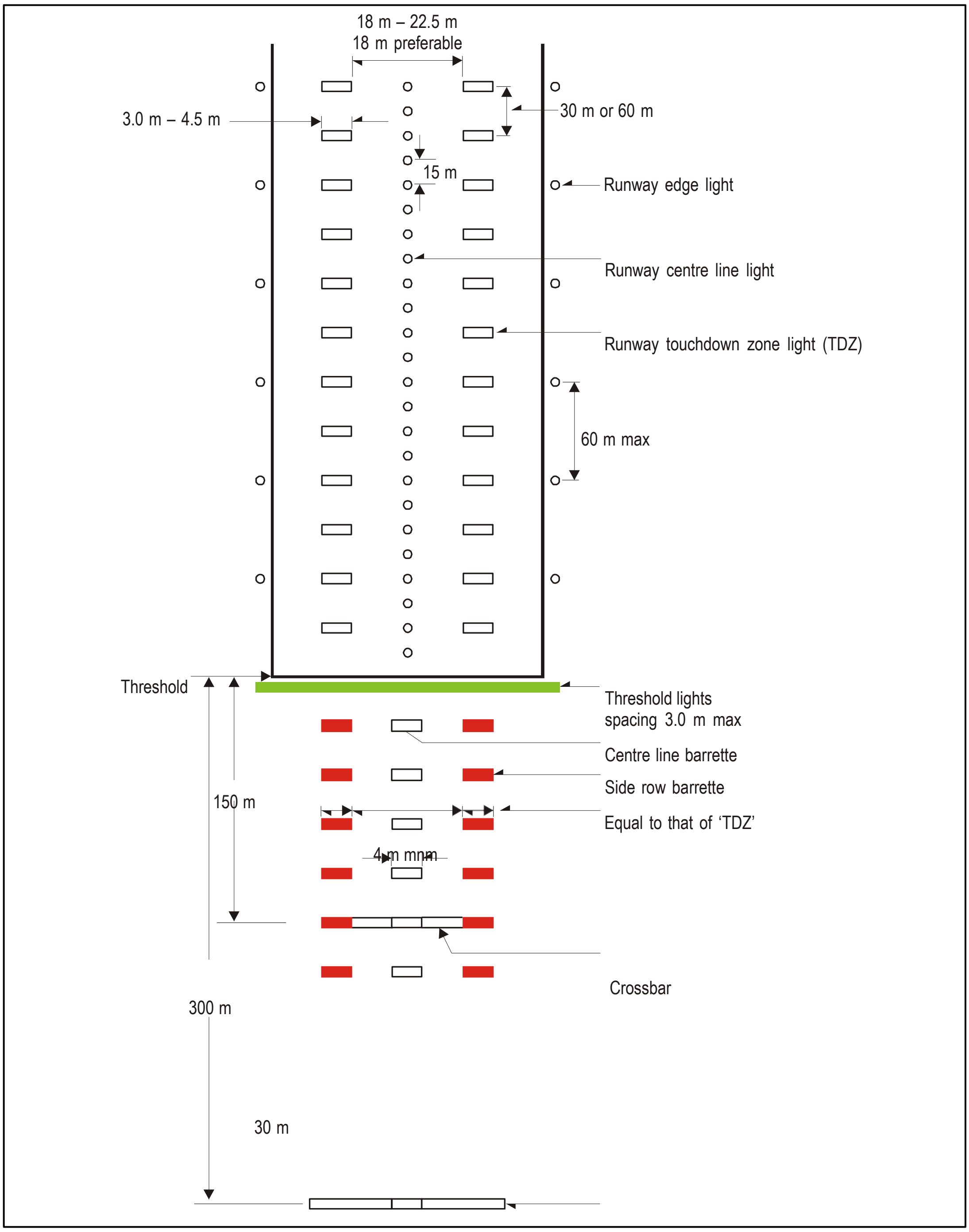
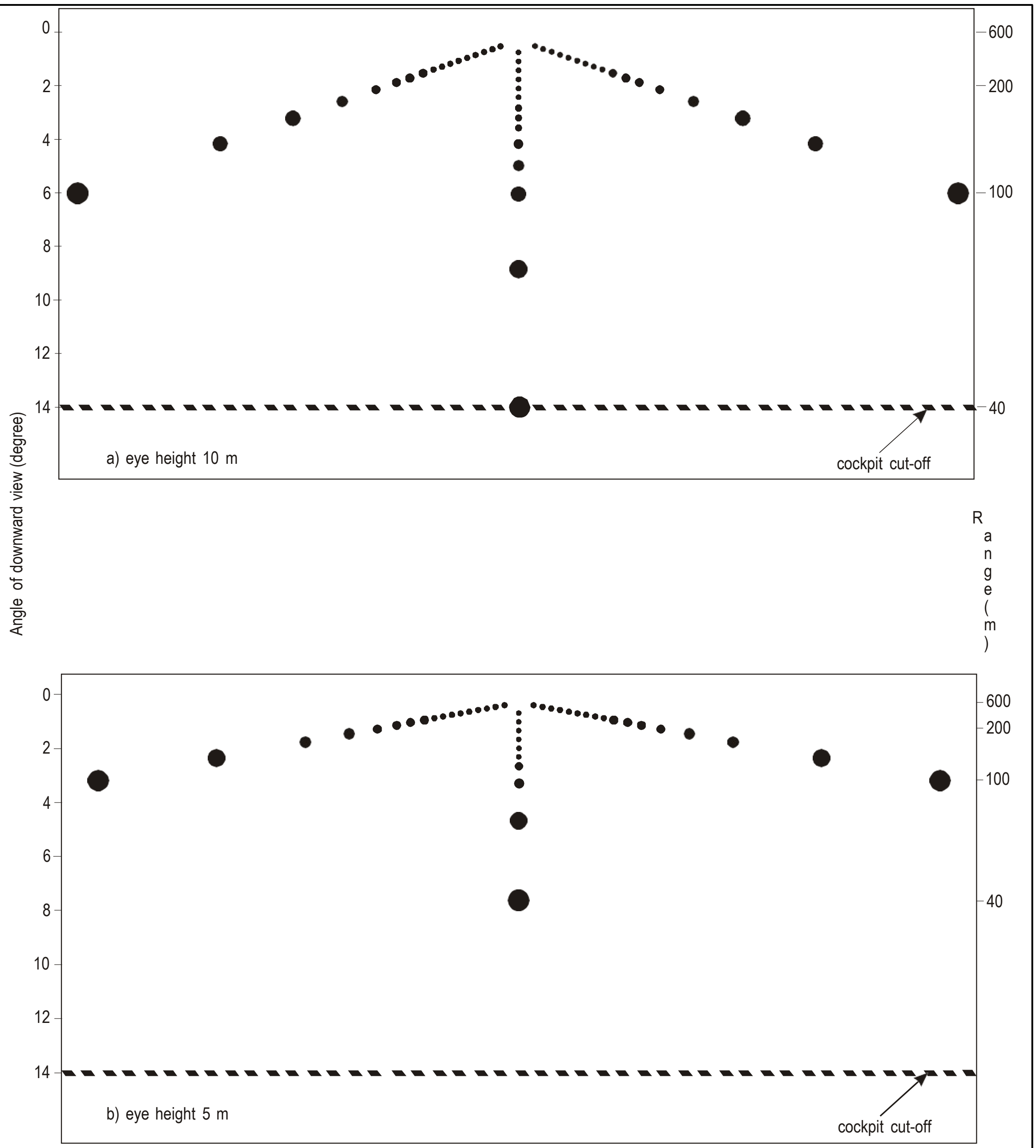



Figure 4-3: Inner 300 m approach and runway lighting for precision approach runways Categories II and III




*Notes.—* Edge lights : 60 m
spacingCentre line lights : 30 m
spacing
Pilot eye height : 10 m and 5 m
Runway width :
60 m Viewing distance for
diagram : 30 cm

Figure 4-4: Edge and centre line lights as seen by a pilot during landing and/or take-off runs

# 5 Human Observer System

## 5.1 Introduction

5.1.1 Before the introduction of instrumented RVR systems, the method of assessing RVR was based on visual observations using lights or special markers, performed by a human observer. In some States it is still the only system available; while in others, it is retained as a standby system for use in case of failure of the instrumented system. Due to its inherent weaknesses (4.3.1 refers), the human observer method should be used only under the following circumstances:

a) at aerodromes with low frequency of occurrence of fog, or any other weather phenomena reducing RVR below 1 500 m (not recommended for Categories II and III);

b) for non-precision approach runways; and

c) as a back-up in case of failure of the instrumented system (not recommended for Categories II and III).

## 5.2 Visual Observations Using Lights

5.2.1 In the visual observation method using lights, the RVR should ideally be assessed at a height of 5 m above the centre line of the runway and the observer should count runway lights from the runway threshold or from the touchdown zone. If it were possible to assess RVR this way, the observing position would correspond best to what the pilot sees. However, during flight operations, the observer, with the observation vehicle, must be removed from the runway and its immediate area so that the obstacle provisions of CAD 14 — Aerodromes, Volume I — Aerodrome Design and Operations are fulfilled. Because it is also necessary for continuous RVR information to be available to the pilot during flight operations, it is clear that human RVR assessments cannot be made from the runway itself. Instead, an observing position is chosen so that continuous RVR assessment can be carried out from a safe location. Moreover, RVR observing structures are made as frangible as possible consistent with their purpose. In all applications of human observer RVR systems, the observers should meet a specified vision standard and be subject to periodic vision checks.

*Note. — Where specific local conditions, such as sloping terrain or occurrence of snow banks, make it impracticable to assess RVR from a location outside the runway, it may be assessed from the runway itself. Under these circumstances, it is necessary that arrangements are in force to ensure that all mobile objects are removed from the runway during its use for landing and take-off.*

5.2.2 Normally, the runway edge lights on the side of the runway opposite the observing position are counted; centre line lights, being flush fittings, are not sufficiently visible therefrom. (Furthermore, runways with centre line lights tend to be equipped with instrumented RVR systems.) Using the far side lights provides a better assessment of conditions along the runway than would be achieved by using the same side lights. In a basic human observer system, the straight-line distance from the observing position to each light is measured and this becomes the reported RVR, but this method has considerable inaccuracy, albeit on the conservative (safe) side if the light intensity is not uniform over all angles of azimuth (see 5.3). The edge lights are usually 60 m apart, except at taxiway intersections, where the distance is different (e.g. 120 m). The RVR assessed visually is the distance in the runway direction between the observer and the furthest visible edge light. A simple conversion table is often compiled relating the number of observed lights to RVR to be reported. An example of a conversion table is given in Table 5-1.

5.2.3 Counting runway edge lights that are visible on either the near or far side of the runway is a difficult task because the edge lights may become confused with other white lights on the aerodrome; also, the observer's perception of the spacing between lights becomes progressively less as range increases making it difficult to accurately count the number of lights. Therefore, some States use separate lights — identical to the runway lights in use and varied in intensity in the same way — for assessing RVR. Because the observer and the light rows used are beyond the obstacle limits, RVR assessments can be made during flight operations provided that these lights do not give a false indication of the runway position to pilots (see CAD 14, 5.3.1.2). Some systems include the possibility of switching separate lights on and off to assist the observer. The use of separate light rows requires special calibration procedures (see 5.3), which may be difficult to perform. These kinds of lights also need periodic cleaning like the runway lights.

## 5.3 Calibration of Visual Observations

5.3.1 Because the RVR assessment point is different from that located at a height of 5 m above the centre line of the runway, a calibration of the system must be carried out. The calibration is also important when special, dedicated light rows, in lieu of edge or centre line lights, are used. It is done by simultaneous counting by at least two observers of the number of lights visible from: a) the observing point (often located on the ground) and b) the reference point, i.e. the centre line of the runway at a height of 5 m. This must be carried out in a variety of visibilities covering the required reporting range of RVR. Based on a statistically sufficient sample of paired observations, a conversion table similar to the example shown in Table 6-1 is built up. Theoretically, the conversion table should be based on various conditions of ambient light illumination (e.g. night, twilight, day, bright day).

5.3.2 The method described in 5.3.1 is difficult to apply since relevant visibility conditions for calibration purposes are not readily available. Alternatively, the calibration can be determined from a knowledge of the light intensities beamed towards the observer and the pilot.

| *Number of edge lights visible to an observer at the observing position* | *RVR observed (in m)* | *RVR to be reported (in m)* |
|---|---|---|
| 1 | 50 | 50 |
| 2 | 110 | 100 |
| 3 | 170 | 150 |
| 4 | 230 | 225 |
| 5 | 290 | 275 |
| 6 | 350 | 350 |
| 7 | 410 | 400 |
| 8 | 470 | 450 |
| 9 | 530 | 500 |
| 10 | 590 | 550 |
| 11 | 650 | 650 |
| 12 | 710 | 700 |
| 13 | 770 | 750 |
| 14 | 830 | 800 |
| 15 | 890 | 800 |
| 16 | 950 | 900 |
| 17 | 1 010 | 1 000 |
| 18 | 1 070 | 1 000 |
| 19 | 1 130 | 1 100 |
| 20 | 1 190 | 1 100 |
| 21 | 1 250 | 1 200 |

Table 5-1: Sample conversion table in the case where the edge lights are 60 m apart and where the first light is 50 m from the observer. The minimum and maximum values reported are 50 and 1 200 m, respectively.

## 5.4 Visual Observations Using Special Markers Along the Runway Edge

5.4.1 If a runway is used at night, it should be equipped with runway edge lights, in accordance with CAD 14, Volume I, 5.3.9.1. These edge lights can also be used to assess RVR as described in 5.2 above. Furthermore, at night, any surface markers would not be visible enough for assessing RVR. However, for visual observations in daylight, a row of special markers placed near the runway would be useful for assessing RVR.

5.4.2 The visual markers may be placed in rows near the observing point, considering the obstacle clearance provisions for runways. Furthermore, the markers should be such that the pilots would not confuse them with the edge markers of the runway (CAD 14, Volume I, 5.5 refers). The markers are usually in the form of triangular prisms on their sides or vertical rectangular boards, and they are painted so that they present the appearance of two surfaces, 1 to 1.5 m2, side by side, one black (or red) and one white. They are set up at distances of 4 to 10 m from the runway edge, most often on the opposite side from an observer, and are usually spaced at regular intervals up to 100 m apart. This results in a slightly irregular series of steps in the observing scale because the line of sight from an observer to the markers is not parallel to the runway. This difficulty can be overcome by using a variable spacing of markers designed to give uniform steps in the observing scale.

## 5.5 Errors with Human Observer Systems

5.5.1 Ideally, the RVR reported should correspond to the conditions on the runway experienced by the pilot when landing or taking off. However, errors in the visual observations occur due to a number of factors:

a) Differences in the exposure to lights. Significant differences may occur in the background luminance and extraneous lights to which an observer and a pilot are exposed. This can be important where observations are not made at the runway centre line (e.g. using a separate row of lights in a direction different from that of the runway in use).

b) Variations in vision among observers. Pilots must check their eyesight periodically and have generally high demands on their vision, but this does not necessarily apply to personnel making RVR assessments. A group of observers may have a different distant visual acuity, significant variations in the visual threshold of illumination in different background luminance conditions or other degraded vision characteristics.

c) Exposure of an observer to high levels of illumination. If this happens just before making visual observations using lights, as would be the case when an observer leaves a lighted area to make night observations, it would degrade the observer’s ability to see the lights, and the RVR values would be underestimated, which could result in the unnecessary deviations of aircraft to alternative aerodromes. This difficulty can be overcome by allowing several minutes for adjustment to illumination conditions outside the station.

d) Beaming of the runway edge lights. The runway edge lights are so directed that the beam intensities have a high value at the runway centre line while the intensity falls off rapidly towards the edges. Because runway lights are not observed at the centre line, the intensities directed towards the observer are lower. If the calibration of visual observations as described in 5.3 is not undertaken carefully, errors in reported RVR values will occur.

# 6 Transmission and Reporting Practices

## 6.1 Methods of Transmission and Display Of RVR

6.1.1 Where assessed by instrumented RVR systems, the RVR must be presented automatically in the meteorological station using digital real-time RVR displays; equivalent RVR displays, related to the same locations of observation and connected to the same measuring devices, must be installed in the appropriate air traffic services (ATS) units (CAD 3, Appendix 3, 4.3.3.1, and CAD 11, 7.1.4.4, refer).

6.1.2 The usual method of transmitting human RVR assessments from the runway observing site to the ATS unit is by telephone or radiotelephone. Practice varies with regard to the stage at which observations of lights or markers are converted into RVR. In some cases, the observer makes the conversion; in others, the number of lights or markers visible is reported to the tower and the conversion is made there.

## 6.2 Reporting Procedures

6.2.1 RVR information is included in local routine reports, local special reports, METAR and SPECI whenever either the visibility or RVR is observed to be less than 1 500 m (see 4.2.3). These reports are passed to aircraft by ATS units, data links (i.e. D-ATIS, D-VOLMET) and/or aeronautical broadcasts (i.e. ATIS, VOLMET). They are also available through various dissemination systems to pilots and aeronautical personnel on the ground at the local aerodrome and at many other aerodromes for briefing or other purposes.

6.2.2 Those responsible for carrying out the human observations should report RVR to the appropriate local ATS unit(s) whenever there is a change in the value to be reported in accordance with the reporting scale in use. According to CAD 3, Appendix 3, 4.3.3.2, arrangements for the transmission of the reports to the ATS units concerned should be such that transmission is normally completed within fifteen seconds after the termination of the observation. However, where RVR is assessed with instrumented systems, with the corresponding displays at the appropriate ATS units (see 6.1.1 above), arrangements are normally in force for the use of these displays to meet the needs of local routine reports and local special reports, eliminating the need to report changes in RVR to the local ATS units.

6.2.3 Special reports (i.e. both local special reports and SPECI) should be made when the RVR changes to or passes values that most closely correspond with the operating minima of the operators using the aerodrome and 50, 175, 300, 550 or 800 m, which correspond to the agreed changeover value between categories of operation being supported at airports. However, where real-time displays exist in the ATS units (see 6.1.1 above), local special reports prompted by changes in

RVR need not be issued (provided that arrangements have been made to use this display in view of meeting the needs for local routine reports and local special reports). Meanwhile, SPECI are required to be issued; a SPECI representing a deterioration in RVR should be disseminated immediately after the observation, while one representing an improvement in RVR should be disseminated only after the improvement has been maintained for 10 minutes.

6.2.4 In local routine reports and local special reports, the value for the touchdown zone (about 300 m from the threshold) should be included without any indication of location, if the RVR is assessed from only one location along the runway. If, however, the RVR is assessed from more than one location along the runway, the value representative of the touchdown zone should be given first, followed in sequence by the values representative of the mid-point (if available) and stop-end. The locations for which these values are representative should be indicated as “TDZ”, “MID” and “END”, respectively. The detailed structure of the reports is included in Table 6-1.

6.2.5 In METAR and SPECI, only the value representative of the touchdown zone should be given, and no indication of location on the runway should be included. When there is more than one runway available for landing, touchdown-zone RVR values for all such runways, up to a maximum of four, should be included. The selection of the four runways to be included should be in accordance with the agreement between the authorities and the operators concerned. The runways to which the values refer should be indicated in the form shown in Table 6-2 which displays the detailed structure of METAR and SPECI.

## 6.3 Range of Values to Be Reported

6.3.1 The lower limit of the reporting range should be 50 m. Below this limit, reports should merely indicate that the RVR is less than 50 m, as shown in Tables 6-1 and 6-2. When the RVR is below the minimum value that can be determined by the system in use, it should be reported using the abbreviations “BLW” (in local routine reports and local special reports) and “M” (in METAR and SPECI) followed by the minimum value that can be determined by the system.

6.3.2 The upper limit of the reporting range should be 2 000 m. Above this limit, reports should merely indicate that the RVR is more than 2 000 m, as shown in Tables 6-1 and 6-2. When the RVR is above the maximum value that can be determined by the system in use, it should be reported using the abbreviations “ABV” (in local routine reports and local special reports) and “P” in (METAR and SPECI) followed by the maximum value that can be determined by the system.

## 6.4 Steps in The Reporting Scale

6.4.1 Because of operational decisions, sometimes with legal implications, taken on the basis of RVR reported, some precision in the reporting scale is essential. Too fine a scale is not justified, since RVR values cannot be completely representative of viewing conditions from the cockpit because of variations in time and space and the limitations of observing techniques.

6.4.2 CAD 3, Appendix 3, 4.3.6.1, specifies that a reporting step of 25 m shall be used up to 400 m RVR, a reporting step of 50 m shall be used between 400 and 800 m RVR and a reporting step of 100 m shall be used for values of RVR above 800 m. Table 6-3 displays the ranges and resolutions of RVR information included in meteorological reports. Any observed RVR value that does not fit the reporting scale in use should be rounded down to the nearest lower reporting step in the scale.

| Detailed content | Template | Examples |
|---|---|---|
| Name of the element | RVR | RVR RWY 10 BLW 50M |
| Runway [2] | RWY nn[L] or RWY nn[C] or RWY nn[R] | RVR RWY 14 ABV 2000M |
| Runway section [3] | TDZ | RVR RWY 32L 400M |
| RVR | [ABV or BLW] nn[n] M | RVR RWY 16 TDZ 600M MID 500M END 400M |
| Runway section [3] | MID | RVR RWY 26 500M RWY 20 800M |
| RVR | [ABV or BLW] nn[n] M | RVR RWY 20R 500M |
| Runway section [3] | END | RVR RWY 12 ABV 1200M |
| RVR | [ABV or BLW] nn[n] M | RVR RWY 10 BLW 150M |

Table 6-1: Structure of RVR information included in local routine reports and local special reports [1]

*Notes. —*

1. *To be included if visibility or RVR < 1 500 m;*
2. *To be included if more than one runway in use;*
3. *To be included if RVR is observed from more than one location along the runway.*

| Detailed content | Template | Examples |
|---|---|---|
| Name of the element | R | R10/m0050<br>R14l/P2000 |
| Runway | Nn[L]/ or nn[C]/ or nn[R]/ | R32/0400<br>R16/0650 R16c/0500 R16R/0450<br>R17L/0450 |
| RVR | [P or M]nnnn | R10/M0050<br>R20/P000 |
| RVR past tendency [2] | U, D or N | R12/P1200U<br>R10/M0150V0500D |

Table 6-2: Structure of RVR information included in METAR and SPECI [1]

*Notes. —*

1. *RVR to be included if visibility or RVR < 1 500 m for up to a maximum of four runways.*
2. *To be included if the ten-minute period preceding the observation has shown a distinct tendency such that the mean RVR during the first five minutes varies by 100 m or more from the mean during the second five minutes of the period.*

| Element | | Range | | Resolution |
|---|---|---|---|---|
| | | Local routine report and local special report | METAR andSPECI | |
| Runway | (no units) | 01 – 36 | 01 – 36 | 1 |
| RVR | M<br>M<br>M | 0 – 400<br>400 – 800<br>800 – 2000 | 0000 – 0400<br>0400 – 0800<br>0800 – 2000 | 25<br>50<br>100 |

Table 6-3: Ranges and resolutions for RVR information included in local routine reports and local special reports

## 6.5 Averaging Period and Updating Frequency

*Note. — Requirements for averaging and updating of RVR cannot be met by the human observer system.*

6.5.1 Fluctuations tend to be over-emphasized by transmissometers and forward-scatter meters because they sample the atmosphere over a distance that is usually shorter than the visual range. Averaging can eliminate or, at least, reduce this over-emphasis. At the same time, it can make observations representative of a larger area than the immediate neighbourhood of the instrument where the atmosphere is sampled. However, averaging must not be carried so far that important variations and trends are obscured. CAD 3 recognizes these points by specifying that instrumented measurements shall be averaged over a period of one minute.

6.5.2 RVR sometimes fluctuates rapidly by several hundred metres in less than a minute. Fog studies have shown that such large changes can occur when the front of a bank of fog passes across an airport. However, large and rapid excursions in indicated RVR may occur during periods of shallow fog. These are generally caused by slight variations in the height of the fog top, which, while alternately covering or exposing the measurement path or volume, have little genuine operational significance. Large changes can also result from isolated fog patches encountering an instrument as they drift in light winds. Thus, as already stressed in Chapter 3, large fluctuations in RVR are difficult to interpret, particularly when radiation fog is forming, and the computed values do not necessarily represent the actual RVR. However, rapid changes in visual range create difficulties for ATS units when passing information to aircraft; some smoothing of observations, by averaging over a period of time, is therefore desirable.

6.5.3 In local routine reports and local special reports, an average period of one minute should be used. In some cases, simple averaging is carried out every minute by the RVR computer; in others, the most recent one-minute running mean value of RVR is displayed in real-time. In METAR and SPECI, the RVR reported should be the mean value during the ten-minute period immediately preceding the observation. If a marked discontinuity in RVR values occurs during the ten-minute period, only those values occurring after the discontinuity should be used to obtain the mean values.

*Note. — A marked discontinuity is considered to have occurred when there is an abrupt and sustained change in RVR, lasting at least two minutes, which reaches or passes through the RVR criteria for the issuance of SPECI (i.e. 175, 300, 550 or 800 m).*

6.5.4 CAD 3, Appendix 3, 4.3.4, specifies that instrumented measurements must be updated at least every 60 seconds to permit the provision of current, representative values of RVR. The periods between updating times of RVR data are mainly between one (i.e. a typical sampling rate) and 60 seconds (i.e. maximum permitted by CAD 3 provisions).

## 6.6 Indication of Variations of RVR In METAR and SPECI

*Note. — The variations of RVR cannot be indicated by the human observer system.*

6.6.1 Additional information concerning the variations of RVR is included in METAR and SPECI. All these variations refer to the ten-minute period immediately preceding the observation. The inclusion of this information requires that the instrumented RVR system calculates and stores the RVR values as follows:

a) ten-minute period immediately preceding the observation;

b) two five-minute periods preceding the observation;

c) and ten one-minute periods preceding the observation.

6.6.2 If the RVR values (during the ten-minute period) have shown a distinct tendency, i.e. the mean during the first five minutes varies by 100 m or more from the mean during the second five minutes of the period, this should be indicated by the abbreviation “U” for an upward tendency, and the abbreviation “D” for a downward tendency. If there is no distinct tendency during the ten-minute period, this should be indicated by using the abbreviation “N” (for example, see Table 6-2). When indications of tendencies are not available, none of the three abbreviations should be used.

6.6.3 If a marked discontinuity in RVR values occurs during the ten-minute period, only those values occurring after the discontinuity should be used to obtain the variations. (For the definition of a marked discontinuity, see Note under 6.5.3).

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