CHAPTER 3

VISIBILITY

3.1. INTRODUCTION

Visibility is defined as the greatest distance at which an object can be seen and recognized in daylight, or at night could be seen and recognized if the general illumination were raised to a daylight level. The criterion of recognizing an object must be used and not merely the seeing of an object without recognizing what it is. For meteorological purposes it is necessary that visibility observations give a measure of the transparency of the atmosphere. Other factors, however, affect the range at which an object can be seen (e.g. its size, colour, background, etc.—see 3.2.1). By selection of appropriate objects and when observing in suitable conditions the effect of these extraneous factors can usually be eliminated in daylight and a meteorological visibility dependent only on the optical state of the atmosphere can be observed. The visibility at night, as defined above, cannot of course be observed. In practice, lights may be used instead of objects, but the range at which lights can be seen depends not only on the atmospheric transparency but also on other factors such as the luminous intensity of the light source and the illumination of the background (see 3.4). A relationship must be established between the visual range of the lights at night and the equivalent daylight meteorological visibility.

In order to improve the scientific basis of visibility measurements, the World Meteorological Organization (WMO) recommended in 1957 the adoption of a new measure of the optical state of the atmosphere—the meteorological optical range (MOR). This is defined as the length of path in the atmosphere to reduce the luminous flux in a collimated beam from an incandescent lamp at a colour temperature of 2700 K to 0·05 of its original value. This unit depends solely on the atmospheric transparency along the path. The MOR can be measured accurately with suitable instrumentation both by day and by night.

The visual extinction coefficient, σ, is defined as the fractional reduction in luminous flux (Φ) of a collimated beam of monochromatic light in unit distance (s), i.e.

$$\sigma = -\frac{1}{\Phi}\frac{d\Phi}{ds}.$$

Integrating,

$$\frac{\Phi}{\Phi_0} = e^{-\sigma s},$$

where the luminous flux is reduced from Φ_0 to Φ in distance s. Thus the MOR (M), by definition, can be obtained from

$$\frac{\Phi}{\Phi_0} = 0{\cdot}05 = e^{-\sigma M},$$

$$\text{or } M = \frac{-\log_e 0{\cdot}05}{\sigma}. \qquad \ldots (1)$$

Koschmieder (as quoted in Middleton*) has shown that the meteorological visibility in daylight (V) is related to σ by the equation

$$V = \frac{-\log_e \epsilon}{\sigma}, \qquad \ldots (2)$$

where ϵ is the threshold of contrast between the object and its background to allow the object just to be recognized. The value of ϵ is believed to be about 0·05; this value gives equality between M and V. Thus, if σ is measured from observations of lights at night, the MOR which is equivalent to the daylight visibility can be approximately obtained from equation (1).

Although meteorologists are primarily interested in the MOR and their observations of visibility are aimed at measuring this, the term 'visibility' is still used almost universally in lieu of MOR and this practice will be followed in this handbook. The lower ranges of visibility are expressed in metres (m) and the higher ranges in kilometres (km).

The practical application of the definition is dealt with in subsequent paragraphs. The advice presupposes an observer with normal eyesight, observing without the aid of binoculars, telescope or theodolite.

3.2. VISIBILITY OBJECTS

The assessment of the visibility in daylight is generally based on the observation of suitable objects at known distances.

3.2.1. Suitability of objects for visibility observations. The principles involved in the selection of the objects are (a) the objects should be black or very dark coloured and stand above the horizon when viewed from the normal observing point, and (b) they should subtend an angle of at least 0·5° in width and elevation to the observer but not more than 5° in width. This upper limit can easily be exceeded with near objects, unless care is taken in selection.

If an object with a terrestrial background has to be selected, it should stand well in front of the background so that the distance between the object and background is at least half that of the object from the observing point. A tree at the edge of a wood, for example, would not be suitable for visibility observations. A white house would be an unsuitable object, particularly when the sun is shining on it, but a group of dark trees would be satisfactory except when brightly illuminated by sunlight.

In order that visibility measurements should be representative and comparable on an international scale, the measurements should refer to objects large enough to subtend an angle of 0·5° at the observer. This angle may be estimated by making a hole 7·5 mm in diameter in a card. When the card is at arm's length such a hole will subtend the specified angle at the observer's eye. The visibility object viewed through such an aperture should completely fill it. As a guide to size, an angle of rather more than half a degree is subtended by an object 1 m wide at 100 m, 10 m wide at 1000 m, and so on in proportion.

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*Middleton, W. E. K. *Vision through the atmosphere.* Toronto, University of Toronto Press, 1952.

Thus, suitable objects need to be of the dimensions of a bush at 100 m, a house at 1000 m, a church at 2 km, and a hill over 150 m high at 15 km. In practice, less bulky objects may have to be selected because objects complying with the specifications are not available. At distances beyond 1000 m where there is a choice of objects to select, the larger should be selected. For distances beyond a few kilometres it is usually necessary to select topographical features such as ridges or hill tops, though these are not ideal objects because they may be hidden at times by a low cloud, or their prominence modified by seasonal features such as a covering of snow.

3.2.2. Selection of visibility objects at synoptic stations. Observations of visibility at synoptic stations, and especially at aerodromes, are of great importance. A good observer should be able to attain an accuracy of reporting to within 10 per cent of the actual visibility, and visibility objects should be carefully and comprehensively selected with this in mind. All suitable objects should be used and, where possible, two or more objects at the same distance but in different directions should be selected as this will enable the observer to recognize differences of visibility in various directions. This latter point is especially important at coastal stations where islands, light-towers, fixed buoys and the distance of the horizon from the height of the observer's eye may all be used to assess visibility across the sea.

3.2.3. Selection of visibility objects at climatological stations. The visibility at a climatological station is not required to the same degree of accuracy as that necessary at a synoptic station. Visibility is recorded as being within one of a series of visibility ranges, and visibility objects should, whenever possible, be chosen at the standard distances given in the table below.

Object	Standard distance	Permissible variations	General description of visibility	Coded entry on monthly return from climatological station
	m	*m*		
—	—	—	Dense fog	X*
A	20	18–22	Dense fog	E
B	40	36–44	Thick fog	0
C	100	90–110	Thick fog	1
D	200	180–220	Fog	2
E	400	360–440	Moderate fog	3
F	1000	900–1100	Very poor	4
	km	*km*		
G	2	1·8–2·2	Poor	5
H	4	3·6–4·4	Moderate	6
I	7	6·3–7·7	Moderate	6
J	10	9–11	Good	7
K	20	18–22	Very good	8
L	30	27–33	Very good	8
M	40	36–44	Excellent	9

*Visibility less than 20 m.

3.2.4. Distance of visibility objects. The distance of selected objects should be carefully determined, preferably by direct measurement for the nearer objects and calculation from a large-scale Ordnance Survey map for the more distant ones.

3.2.5. Record of visibility objects. The selected visibility objects should be listed at climatological stations in Metform 3100A (Supplement to the Pocket Register), and at synoptic reporting stations in the appropriate pages of the Register. A copy of the list should be displayed conveniently for the observer, together with a key map indicating the objects in a diagram or panoramic photographs, and including bearings from the observing point in degrees from true north.

3.3. DETERMINATION OF VISIBILITY DURING DAYLIGHT

3.3.1. General principles. The assessment of the visibility during daylight is generally based on the observation and recognition of suitable objects at known distances. Assuming that the observer has normal eyesight, the distance at which objects of suitable size, as explained in 3.2.1, can be seen depends mainly on such factors as:

(*a*) the transparency of the atmosphere,

(*b*) the position of the sun, and

(*c*) the degree of contrast between an object and the background.

As the visibility should depend only on factor (*a*), it is necessary to take precautions to eliminate the effects of (*b*) and (*c*). Thus if the sun is shining it is desirable to observe objects located at an angle of 90° or more from the sun's direction and, in particular, to avoid viewing an object against a rising or setting sun as this may suggest an exaggerated visibility. Whenever possible, the objects used should be those visible against the sky, or having a good background contrast.

If possible, the observation should be made from a position where the observer has an uninterrupted view of the entire horizon. If this is not possible the observer should change viewpoints until he has viewed the horizon in all directions. As the requirement is for horizontal visibility at the earth's surface, the eye of the observer should be at normal height above the ground; thus measurements should not be made from high buildings.

3.3.2. Observations of visibility. If one of the visibility objects is just recognizable for what it is known to be, then its distance is the visibility. A perfect set of visibility objects (each within 10 per cent of the distance of the next object at synoptic stations, or at each of the standard distances at climatological stations) is rarely, if ever, available. In practice, therefore, when one object is seen with clarity but the next furthest object is either not visible or is blurred or indistinct, then the visibility is somewhere between the distances of the two objects; in these circumstances an estimate of the visibility must be made of the distance at which an imaginary suitable object could be seen and identified, based on the relative clarity and distance of the two known objects.

Visibilities greater than the distance for which objects are available may be estimated from the general transparency of the atmosphere. This can be done by noting the clarity with which the furthest visibility object stands out. Sharp outlines and relief, with little or no blurring of colours, indicates that the visibility is much greater than the distance of the object. If the furthest visibility object, say at 15 km, is seen with the clarity as described above, an experienced observer may estimate the visibility to be 40 km; at places where the horizon is restricted estimations of this kind may frequently have to be made.

Whereas at synoptic stations the aim should always be to observe visibility to an accuracy within 10 per cent, at climatological stations it is necessary merely to record the correct visibility letter as given in the table on page 45. For example, if an object at distance D can be seen, but not the object at distance E, then the correct entry is D. Where suitable objects are not available at all the standard distances, letters should be selected by estimation as indicated above. If the object at distance A cannot be seen, the entry is X.

3.3.3. Visibility varying in different directions. When the visibility varies markedly in different directions the lowest visibility is logged. A note should be made in the remarks column detailing the maximum visibility and the directions from the observer at which this occurs; similarly the direction of the minimum visibility should be recorded together with a brief comment, if appropriate, giving an explanation for the disparity. At stations which make full synoptic reports the maximum and minimum visibility (when the visibility is less than 1000 m) and the associated directions from the observer may be added to reports in the form described in the *Handbook of weather messages,* Parts II and III.

3.3.4. Coastal stations. The visibility to be logged is that over land. If the visibility over the sea is different from that over the land, the seaward visibility should be noted in the remarks column and at full synoptic stations may be added to transmitted reports (as detailed in the *Handbook of weather messages,* Parts II and III) if the station is instructed to do so.

3.4. DETERMINATION OF VISIBILITY AT NIGHT

Visibility reports at night should indicate the same degree of atmospheric transparency as they do by day. The change from daylight to darkness does not itself affect the visibility; if changes do occur they are the result of an alteration in atmospheric conditions.

The most suitable objects for determining the visibility at night are unfocused lights of moderate intensity at known distances and the silhouettes of hills and mountains against the sky.

The list of visibility objects at a station should also include lights suitable for determining the visibility at night.

The distance at which a light can be seen at night depends mainly on the following factors:

(*a*) luminous intensity of the light,

(*b*) sensitivity of the observer's eyes,

(*c*) presence or absence of other bright lights in the field of view,

(*d*) general level of illumination, and (*e*) transparency of the atmosphere.

In determining the visibility from the observation of fixed lights the effects of the first four factors should be reduced as far as possible. In order that the observer's eyes should become as well adjusted as possible, allow at least two minutes in darkness for the eyes to adapt to night vision.

The practical ways of determining the visibility from fixed lights includes the use of the Meteorological Office visibility meter Mk 2 (formerly called the Gold visibility meter) and the use of lights of known luminous intensity (described in section 3.4.3).

3.4.1. Instructions for the use of the Meteorological Office visibility meter Mk 2.

3.4.1.1. *Description of the visibility meter.* The visibility meter (Plate XV) is a simple visual photometer used to measure the luminous flux from a distant light, and hence the transparency of the atmosphere. This is done by observing the lamp through graduated neutral filters which can be varied until the lamp is only just visible. The main filter is about 20 cm long and varies in opacity in a regular manner along its length, being almost transparent at one end. It slides in a frame to which are fixed two small filters (about 2 cm square) whose opacity varies in the same manner as that of the main filter, but in the opposite direction. One of the small filters is almost transparent while the other transmits only about 1/1000 of the incident light. The effect of superimposing either of the two small filters on any part of the main filter gives an area of uniform opacity, which is continuously variable by sliding the main filter. The opacity is measured by two scales, corresponding to the small filters, on either side of the main filter, which move past two fixed marks on the frame. The unit employed is the 'nebule', which is defined by the statement that a filter of opacity 100 nebules transmits 1/1000 of the incident light, which implies that a screen of opacity 1 nebule has a transmittance of 0·933. The scales are linear, running from 15 to 120 nebules for the clearer of the small filters, and 115 to 220 nebules for the denser one.

3.4.1.2. *Installation of visibility lights.* Fixed lights of constant intensity must be used, and it is most convenient to have at least three lights arranged so that there is one at approximately 100, 450 and 1350 m from the observer. The lights should be 2 to 3 m above the ground, and should have some form of hood to protect them from the weather (and from theft), but which is removable to facilitate cleaning and replacing of the lamps. The hood should be black inside and no lens or focusing mirror should be used. A 15-watt lamp should preferably be used at 100 m, a 100-watt at 450 m and a 100-watt (or higher if possible) at 1350 m.

On aerodromes the light should be well screened so as to be visible only from near the observation point, and should be sited so as not to shine along any runway; they must not cause an obstruction to the runway or perimeter track. Approval must be obtained from the aviation authorities before the lights are sited.

It is not essential that the lamps should be switched on and off from near the observation point; it may often be much cheaper to install a switch on the light itself, leaving it on all night. Alternatively the lights could be wired into a road-lighting or obstruction-light circuit, provided it is (or can be) in use all night. Circuits subject to large voltage variations (either deliberate or accidental) must be avoided.

Where the lights are on for long periods, the lamps must be renewed at regular intervals, e.g. monthly in winter and quarterly in summer. The rated life of a domestic tungsten-filament lamp is normally 1000 hours. A tungsten-filament lamp will emit an approximately steady light after having been 'aged' by being continuously lit at its rated voltage for a period of 5 per cent of its rated life, that is normally for 50 hours. It is desirable that the new lamp should be of exactly the same type as the old. Each observer should make new calibration figures every time a lamp is replaced, lamps being aged at the station before use.

The observations are greatly facilitated if the lights are observed through fixed tubes, one for each light. The tubes may be lengths of iron pipe, painted matt black inside, about 1 m long and 3·5 cm in diameter. It is preferable to fix them through the wall of a room, if a suitable room is available, that is one from which all the lights can be seen, and which can be darkened for two minutes before each observation. The advantage of this arrangement are threefold:

(*a*) There is never doubt about which light is being observed, as each tube points directly to its own light.

(*b*) The observer can be in complete darkness, and shielded against any extraneous lights.

(*c*) The observations can be made in greater comfort, especially in cold or wet weather, and will therefore be more reliable.

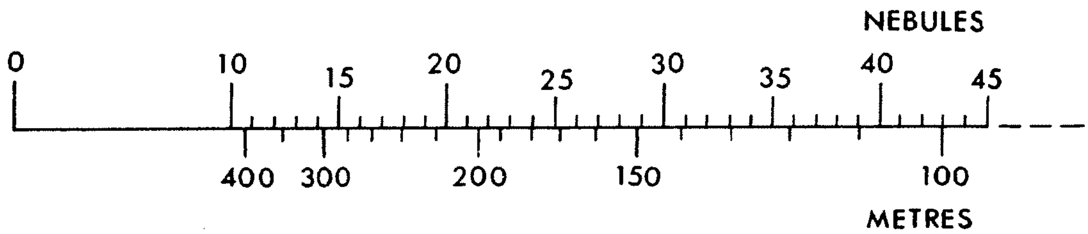
When the observation must be made out of doors, with or without the assistance of tubes, the observing point should be in a position well away from any artificial light.

When the installation is complete, the distance of each light from the observation point should be carefully measured.

3.4.1.3. *Preparation of conversion diagrams.* These are used to obtain the equivalent daylight visibility from the meter readings. A card (Metform 2812, Conversion diagrams for use with visibility meter) contains skeleton diagrams and full instructions for their completion. If this card is not available, diagrams can be prepared locally (one for each light) by marking along a straight line two scales, one of nebules and one of visibility in metres. The two scales must conform with the relation:

$$\text{number of nebules} = 43 \times \frac{\text{distance of light (metres)}}{\text{visibility (metres)}}.$$

The scale should not be extended below 10 nebules unless this is necessary to provide an overlap with the next more distant light. Part of a specimen set of scales applicable to a light at exactly 100 metres is reproduced below.



3.4.1.4. *Individual calibration figures.* Before the meter can be brought into routine use, each observer must determine his calibration figure for each light; this is the meter reading which would be obtained if the atmosphere were perfectly transparent. In practice this should be done immediately after dark on an evening when the visibility has been observed (during daylight) to be not less than 12 times the distance of the light in question from the observer and is not expected to change much, for example when there is a cloudy sky, a fresh wind, and humidity not over 95 per cent. The procedure described in the next section should be carefully followed, and not more than one light should be observed at one time, as the longer time taken would improve the adaptation of the eyes to the dark and thus cause non-representative readings.

An observer, having taken a meter reading M, obtains from it his personal calibration figure for the light in question by calculating the following expression:

$$\text{calibration figure} = M + 0{\cdot}043 \times \frac{\text{distance of light (metres)}}{\text{visibility (kilometres)}}.$$

A calibration book should be kept, with a page for each observer showing his calibration figure for each light and with the date when it was determined. New figures should be determined on every convenient occasion, and comparison with earlier figures will give the best average figure for future use. A recalibration should always be made whenever a lamp is changed.

3.4.1.5. *Routine use of the visibility meter.* The procedure for making an observation with the meter is as follows:

(*a*) Ensure that the glass surfaces of the meter are clean. If necessary, clean them with a lint-free cloth. (When not in use the meter and the cloth should be kept in a closed box.)

(*b*) Allow about two minutes for the eyes to adapt to the darkness before beginning to make an observation.

(*c*) Observe the most distant light which is visible through the visibility meter, and adjust the sliding filter until the light is only just visible. This should be done by pulling out the slide until the light just disappears, then pushing it in slowly until the light just reappears. Always begin with the eyeshield over the clearer small filter, but if the light is still visible with the slide pulled right out, the eyeshield should be transferred to the dark filter. Look directly at the light during the observation as the sensitivity of the eye is more constant for direct vision. Do not spend a long time making an observation as the eyes slowly adapt to the dark and this will invalidate the current calibration figure for an individual. The observer should aim at always spending three minutes between leaving a well-lighted room and completing the observation. If the observer normally wears spectacles for distant vision he should wear them for making observations, but they must be kept clean and free from condensation or rain (as must the meter itself).

(*d*) When the sliding filter has been correctly adjusted the scale reading should be noted, care being taken that the slide is not accidentally moved before being read. The reading should be taken from the scale on the slide on which the eyeshield has been used.

(*e*) This reading should be subtracted from the observer's calibration figure for that particular light; the resulting figure is then used, in conjunction with the appropriate conversion diagram, to read off the visibility.

(*f*) If the difference between the calibration figure and the observed reading is less than 10 nebules, even for the most distant light, the diagrams cannot be used. The visibility is then known to be over 4·3 times the distance of the furthest light and it must be estimated visually. It will be evident that this visibility meter requires more care in its use than the majority of meteorological instruments. Lack of care, for instance in neglecting to allow always the same length of time for the eyes to adapt to the dark, will lead to considerable errors.

3.4.2. Transmissometer. The transmissometer measures the luminous flux of a beam of light after it has passed a known distance through the atmosphere. By comparing the luminous flux with that which would be obtained in perfectly clear conditions, it is possible to calculate the extinction coefficient of the air, and hence the visibility (see equation (1) in 3.1). The design of the transmitter and receiver housings limits the field of view, and hence the effect of background lighting, and this allows the transmissometer to operate both during day and night. The main advantages of the transmissometer over the visibility meter are the independence of sensitivity of the observer's eye and the ability to operate throughout the full 24-hour period.

In the Meteorological Office transmissometer the source of light is a low-voltage projector lamp. The luminous flux of the beam of light from this source, after it has passed through a 200-metre horizontal path of the atmosphere at a height of 3 metres, is measured by means of a photo-electric cell housed in the receiver unit. A means of adjusting the receiver gain is incorporated for calibration purposes. The lamp runs from a stabilized mains supply through a step-down transformer. The range of a transmissometer is related to the baseline, and for the 200-metre baseline the operating range is about 100 metres to 10 kilometres. Within that range the transmissometer will measure visibility to within 11 per cent accuracy whilst giving an indication, at a lower accuracy, outside that range.

The differences between the Mk 3A, Mk 3B and Mk 4 versions are only in the telemetry of data and the processing of the signal. Detailed operating instructions are available from the Operational Instrumentation Branch.

Observers should note that both the visibility meter and transmissometer measure visibility in only one direction and, moreover, over a restricted distance. When using these instruments a visual check should always be made in other directions.

3.4.3. Auxiliary estimates of visibility at night by direct observation of lights. If the visibility meter cannot be used, less precise estimates of visibility can be made by eye observations of lights. To obtain consistent results, all suitable lights should be listed, giving the visibility limits (obtained as described in 3.4.3.3) below which each light becomes invisible. This should be done even at stations where the visibility meter is used, as the experience gained will be of great assistance if the meter becomes unserviceable and is especially useful in determining visibility in different directions.

3.4.3.1. *Luminous intensity and colour of selected lights.* Each selected light must be of constant and known rating and luminous intensity (candela) which should not vary greatly with the direction from which is is viewed: lights fitted with lenses or mirrors to throw the light in certain directions rather than others should not be used. Flashing lights may be used provided each flash lasts for one second or more. The luminous intensity (in candelas) should be ascertained from the engineer or other authority in charge of the lights, or from the manufacturers. Ordinary domestic electric-light bulbs of 100, 60 and 15 watts have luminous intensities of approximately 92, 46 and 9 candelas, respectively. On aerodromes, red obstruction lights on low structures may also be used but, because of the absorptive properties of the red glass, the luminous intensity will then be very much less than that of the bulbs themselves. The following table may be used for obtaining the luminous intensity of standard types of red obstruction lights:

No. of bulbs in the light	Power per bulb (watts)	Luminous intensity (candelas)
4	75	22
2	75	15
2	60	10
2	15	3

Possible unserviceability of one or more of the bulbs and dirt or ice on the glass covers would reduce the above values of luminous intensity emitted, and the resulting estimate of visibility would be below the actual visibility.

Alternatively the luminous intensity of the light can be measured with the visibility meter on a night of good visibility (15 km or more). The observer should stand at a carefully measured distance from the light, between 10 and 100 metres according to its intensity, and should adjust the visibility meter until the light is only just visible through it. This should be completed three minutes after leaving a lighted room. If the meter reading is N (nebules) and the distance from the light is D (metres), the intensity I (candelas) is given by:

$$\log I = 0{\cdot}03N + 2 \log D - k$$

where the value of k should be taken as

6 during twilight
6·7 in moonlight
7·5 in complete darkness.

The selected lights should preferably be white.

3.4.3.2. *Visual threshold.* The sensitivity of the eye is expressed in terms of the visual threshold: the illumination produced at the eye by a light so faint that it can only just be seen. It varies somewhat from one observer to another and for the same observer at different times. For practical purposes average values have been used in preparing Figures 4(a), (b) and (c) corresponding to (a) twilight or when there is appreciable light from artificial sources, (b) moonlight or when it is not quite dark, and (c) complete darkness or with no light other than starlight.

Except for red light, the sensitivity of the eye for indirect vision (looking a little to one side of the light) is greater than for direct vision after a few minutes have been spent in the dark. The eye's sensitivity for indirect vision (again except for red light) continues to increase for an hour or more after the observer has gone from a lighted room into weak illumination or darkness, whereas dark adaption for direct vision is complete in about two minutes. Indirect vision should therefore not be used for visibility observations, and observers must make sure that for this purpose they regard a light as visible only if they can see it when looking directly at it.

3.4.3.3. *Use of nomograms to determine visibility.* The relation between daylight visibility and the distance at which a light is just visible at night is given in Figures 4(a), (b) and (c). Each nomogram shows the distances at which lights of varying luminous intensity (from 1 to 1 000 000 candelas) are just visible when the equivalent daylight visibility has any value between 10 metres and 10 kilometres. The horizontal line corresponding to the distance of the light from the observer should be followed until it meets the curve corresponding to its luminous intensity (interpolating as necessary). The abscissa of this point gives the equivalent daylight visibility, and this should be inserted in the list referred to in 3.4.3.

It is essential that the appropriate nomogram is used, and three separate lists made for the specified conditions.

When very powerful lights are observed in poor visibility they may themselves make the background so bright as to raise the observer's visual

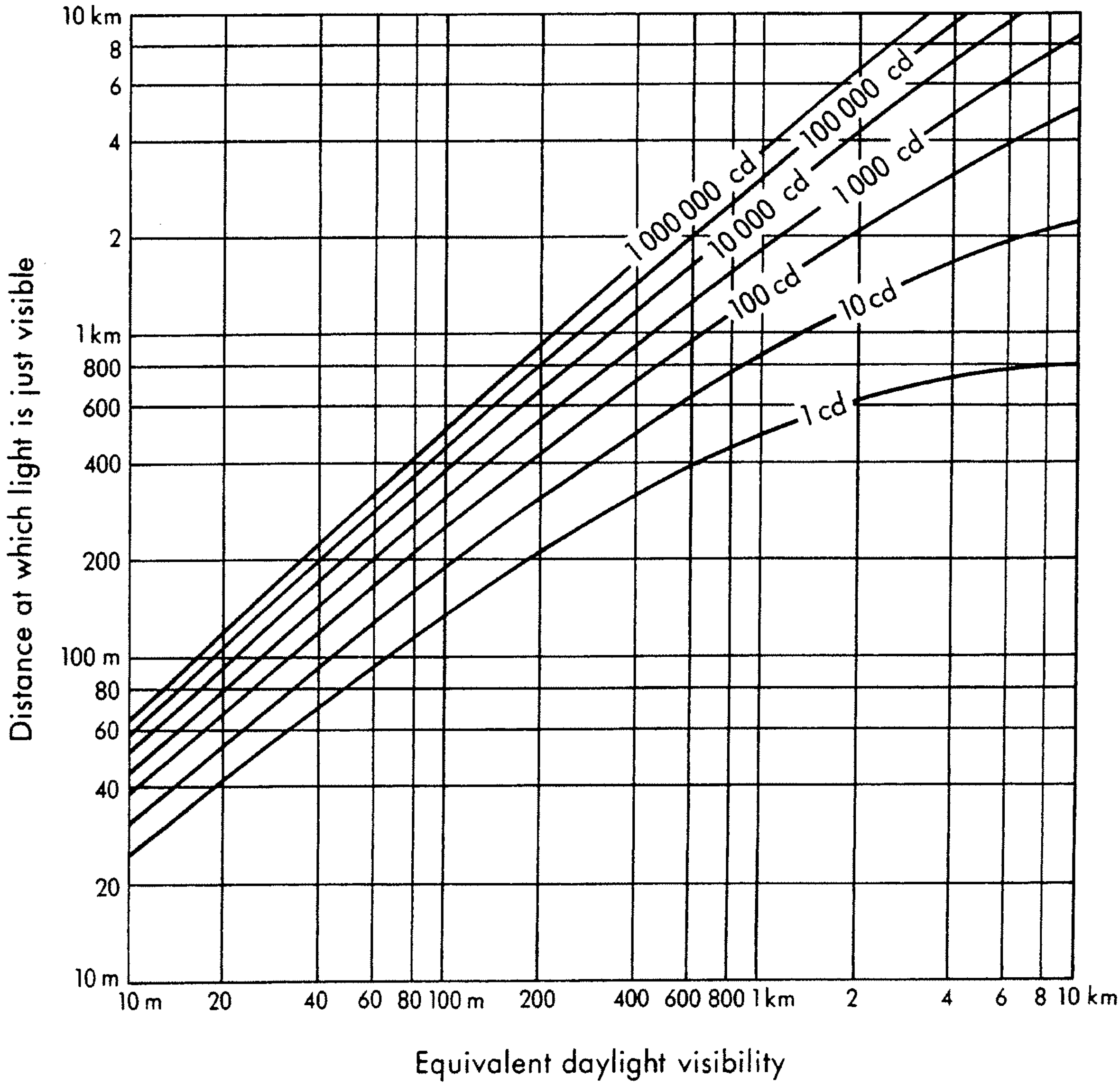


Figure 4(a). Twilight nomogram of visibility of lights at night threshold. This effect is too variable to be readily allowed for, and the use of such lights for visibility observation should be avoided.

Figures 4(a), (b) and (c) are based on the equation of diminution of light in the atmosphere

$$E_t = \frac{I}{L^2} e^{-\sigma L}$$

and Koschmieder's formula (given earlier in equation (2) in 3.1)

$$V = \frac{-\log_e \epsilon}{\sigma},$$

where

I = luminous intensity of light (candelas),
L = distance at which light can just be seen at night (metres), and
E_t = threshold of illumination of the observer's eye for point-light sources at night (lux).

It is assumed that $E_t = 10^{-6}$, $10^{-6.7}$ and $10^{-7.5}$ lux, respectively, for twilight, moonlight and darkness, and $\epsilon = 0{\cdot}05$. These values are recommended by WMO.

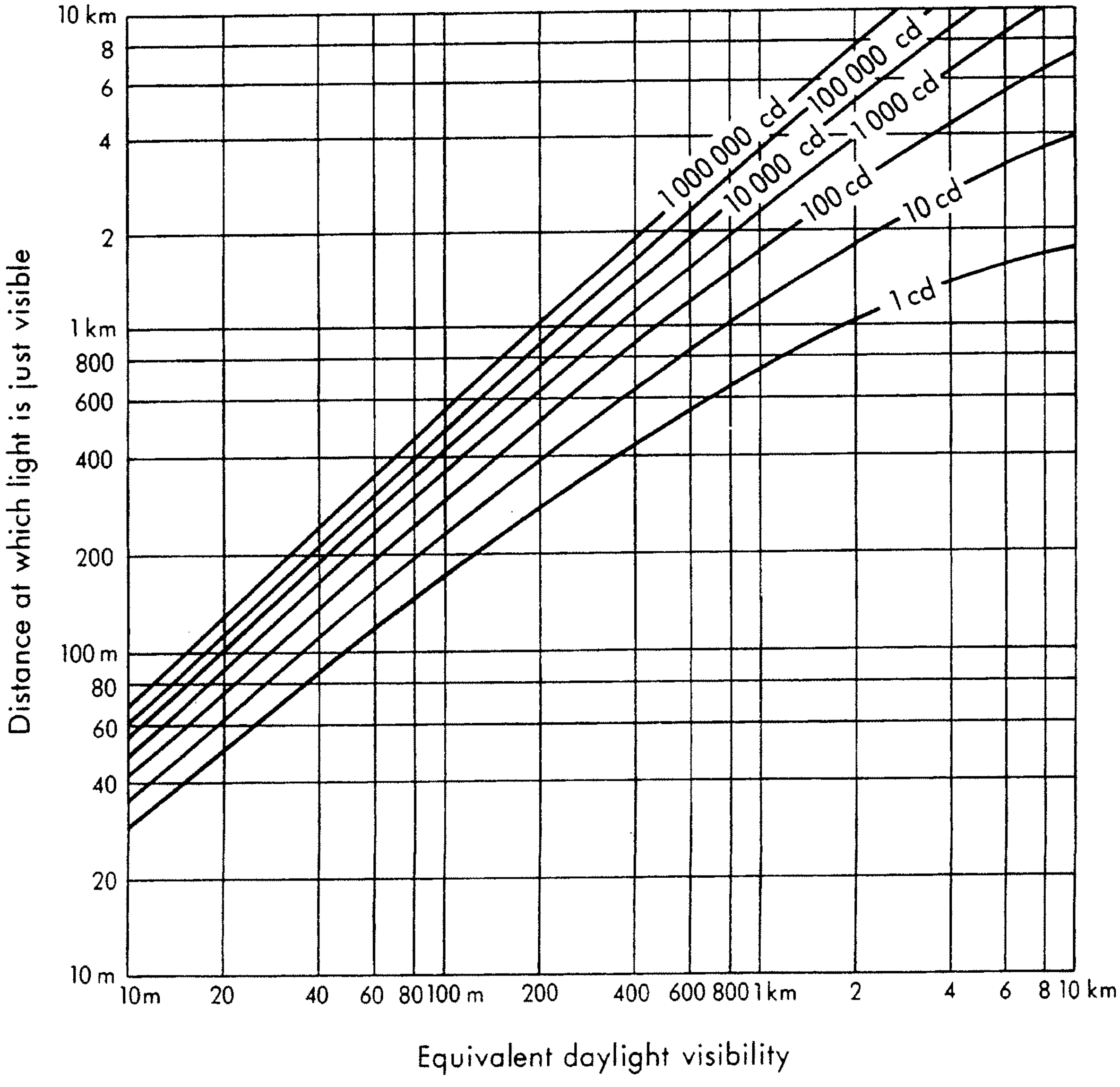


Figure 4(b). Moonlight nomogram of visibility of lights at night

It is easily seen from Figures 4(a), (b) and (c) how misleading visibility observations can be if they are based simply on the distance at which ordinary lights are visible, without due allowance for the intensity of the light.

3.5. VERTICAL VISIBILITY

When the sky is obscured because of fog, falling or blowing snow or some other obscuring phenomena, observers are required to measure or estimate the vertical visibility in place of cloud height.

The vertical visibility is defined by the World Meteorological Organization as the vertical visual range into an obscuring medium. In the United Kingdom this definition is interpreted as the visual range of a dark object of moderate size viewed vertically upwards against a sky background in daylight.

Vertical visibility, as defined for United Kingdom use, cannot be estimated in darkness, nor can it be measured by either the cloud searchlight or cloud base recorder, because neither of these instruments measure visual range.

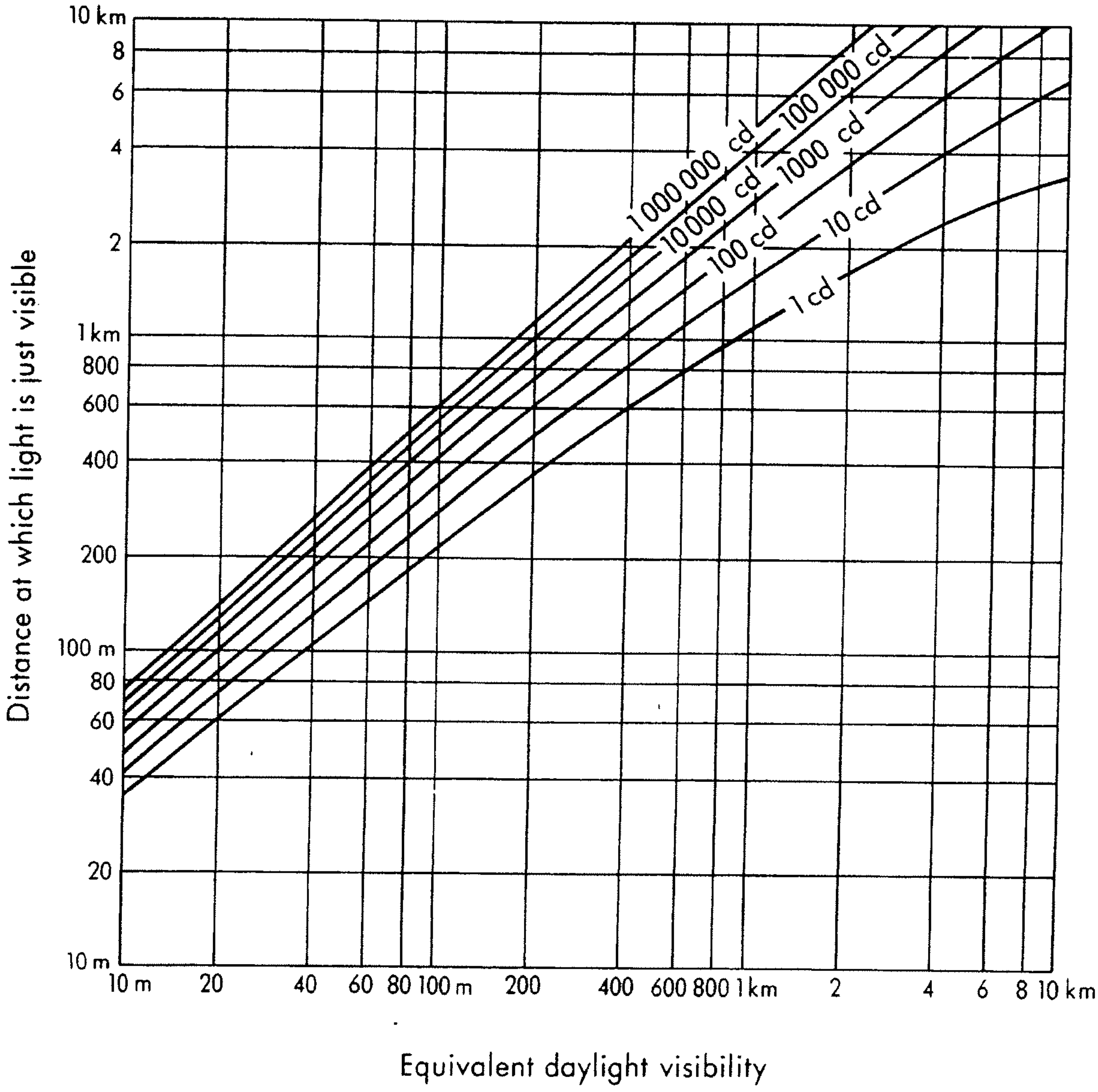


Figure 4(c). Darkness nomogram of visibility of lights at night

The vertical visibility may be taken as the height above ground at which a pilot balloon, *if rising vertically,* would disappear from view in daylight.

When the obscuring medium is so dense that the tops of tall structures are invisible from a point near their base, an estimate of vertical visibility can be made if the observer knows the height above ground of various points on the structures. An open structure, such as a lattice mast, is preferable to a solid building.

If the observer has no basis for making an estimate which he considers reasonably reliable he should omit the observation. The method of reporting vertical visibility is described in the *Handbook of weather messages,* Part II, and *Abbreviated weather reports*.

3.6. RUNWAY VISUAL RANGE

Runway visual range (RVR) is defined by the International Civil Aviation Organization (ICAO) as 'the maximum distance in the direction of take-off or landing at which the runway, or specified lights or markers delineating it, can be seen from a position above a specified point on its centre line, at a height corresponding to the average eye-level of pilots at touchdown'. A height of 5 metres above ground level is regarded as corresponding to the average eye-level of pilots at touchdown.

A 'human observer' RVR system has been brought into use at some civil airports and Royal Air Force airfields in the United Kingdom and overseas, whereby an observer (at a known fixed position, as close to the Touch-down Zone as safety allows) can count the number of designated RVR reference lights visible. Knowing this count, and by means of a calibration table supplied by the Meteorological Office, the Air Traffic Controller can obtain the RVR applicable to the Touch-down Zone of the designated runway. At some of the larger civil airports an instrumental RVR system using transmissometers has been installed.