Seychelles Civil Aviation Authority

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Safety and Security Regulation Department

Flight Operations and Flight Crew Licensing Inspectorate

FLIGHT OPERATIONS NOTICE

Number: OPS/N/2023/037

Altimeter Setting Procedures

Flight Operations Notices are intended to provide advice and guidance to illustrate a means, but not necessarily the only means, of complying with the Regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material. Flight Operations Notices should always be read in conjunction with the relevant regulations.

1. Purpose

The purpose of this notice is to provide aircraft operators with the guidance published in ICAO Doc 8168 Procedures for Air Navigation Services, Aircraft Operations (PANS-OPS), Volume III Aircraft Operating Procedures, Section 2 Altimeter Setting Procedures on how to develop the altimeter setting procedures.

2. Applicability

This notice is applicable to all aircraft operators.

3. References

- ICAO Doc 8168 Procedures for Air Navigation Services, Aircraft Operations (PANS-OPS)
  - Volume I, Flight Procedures
  - Volume II, Construction of Visual and Instrument Flight Procedures
  - Volume III, Aircraft Operating Procedures
- ICAO Doc 4444 Procedures for Air Navigation Services, Air Traffic Management (PANS-ATM)
- ICAO Doc 10066 Procedures for Air Navigation Services Aeronautical Information Management (PANS-AIM)
- ICAO Doc 7030 Regional Supplementary Procedures (as applicable to area of operations)

4. Additional Information/Clarification/Queries

Any queries, requests for guidance/clarification or additional information subsequent to this publication should be addressed to General Manager Safety and Security Regulation by mail dalabrosse@scaa.sc or by contacting the SCAA Safety and Security Regulations Flight Operations and Flight Crew Licencing Inspectorate (telephone 4384271).

5. Effective Date

31 August 2023

6. Cancellation

This Notice will remain in force until revoked or replaced by the Authority.

7. Altimeter Setting Procedures

7.1 Introduction to Altimeter Setting Procedures

7.1.1 These procedures describe the method for providing adequate vertical separation between aircraft and for providing adequate terrain clearance during all phases of a flight. This method is based on the following basic principles:

(a) States may specify a fixed altitude known as the transition altitude. In flight, when an aircraft is at or below the transition altitude, its vertical position is expressed in terms of altitude, which is determined from an altimeter set to sea level pressure (QNH).

(b) In flight above the transition altitude, the vertical position of an aircraft is expressed in terms of flight levels, which are surfaces of constant atmospheric pressure based on an altimeter setting of 1013.2 hPa.

(c) The change in reference from altitude to flight levels, and vice versa, is made:

(1) at the transition altitude, when climbing; and

(2) at the transition level, when descending.

(d) The transition level may be nearly coincident with the transition altitude to maximize the number of flight levels available. Alternatively, the transition level may be located 300 m (or 1 000 ft) above the transition altitude to permit the transition altitude and the transition level to be used concurrently in cruising flight, with vertical separation ensured. The airspace between the transition level and the transition altitude is called the transition layer.

(e) Where no transition altitude has been established for the area, aircraft in the en-route phase shall be flown at a flight level.

(f) The adequacy of terrain clearance during any phase of a flight may be maintained in any of several ways, depending upon the facilities available in a particular area. The recommended methods in the order of preference are:

(1) the use of current QNH reports from an adequate network of QNH reporting stations;

(2) the use of such QNH reports as are available, combined with other meteorological information such as forecast lowest mean sea level pressure for the route or portions thereof; and

(3) where relevant current information is not available, the use of values of the lowest altitudes or flight levels, derived from climatological data.

(g) During the approach to land, terrain clearance may be determined by using:

(1) the QNH altimeter setting (giving altitude); or

(2) under specified circumstances (refer to paragraphs 7.2.4.2 and 7.3.5.4 below), a QFE setting (giving height above the QFE datum).

7.1.2 This method provides flexibility to accommodate variations in local procedures without compromising the fundamental principles.

7.1.3 These procedures apply to all IFR flights and to other flights which are operating at specific cruising levels in accordance with 'rules of the air' requirements, ICAO Doc 4444 Procedures for Air Navigation Services — Air Traffic Management (PANS-ATM) or ICAO Doc 7030 Regional Supplementary Procedures as applicable to the respective area of operations.

7.2 Basic Altimeter Setting Requirements

7.2.1 General

7.2.1.1 System of Flight Levels

7.2.1.1.1 Flight level zero shall be located at the atmospheric pressure level of 1013.2 hPa. Consecutive flight levels shall be separated by a pressure interval corresponding to at least 500 ft (152.4 m) in the standard atmosphere.

Note: This does not preclude reporting intermediate levels in increments of 30 m (100 ft). (Refer to ICAO Doc 8168 Procedures for Air Navigation Services, Aircraft Operations (PANS-OPS) Volume III, Aircraft Operating Procedures, Section 4 Secondary Surveillance Radar (SSR), Chapter 1 Operation of Transponders, 1.2, "Use of Mode C".)

7.2.1.1.2 Flight levels shall be numbered according to Table 1 below which indicates the corresponding height in the standard atmosphere in feet and the approximate equivalent height in metres.

7.2.1.2 Transition Altitude

7.2.1.2.1 A transition altitude will normally be specified for each aerodrome by the State in which the aerodrome is located.

7.2.1.2.2 Where two or more closely spaced aerodromes are located so that coordinated procedures are required, a common transition altitude will be established. This common transition altitude will be the highest that would be required if the aerodromes were considered separately.

7.2.1.2.3 As far as possible, a common transition altitude may be established:

(a) for groups of aerodromes of a State or all aerodromes of that State;

(b) on the basis of an agreement, for:

(1) aerodromes of adjacent States;

(2) States of the same flight information region; and

(3) States of two or more adjacent flight information regions or one ICAO region; and

(c) for aerodromes of two or more ICAO regions when agreement can be obtained between these regions.

7.2.1.2.4 The height above the aerodrome of the transition altitude will be as low as possible but normally not less than 900 m (3 000 ft).

7.2.1.2.5 The calculated height of the transition altitude will be rounded up to the next full 300 m (1 000 ft).

7.2.1.2.6 Despite the provisions in 7.2.1.2, “Transition Altitude”, a transition altitude may be established for a specified area on the basis of regional air navigation agreements.

7.2.1.2.7 Transition altitudes shall be published in aeronautical information publications (AIP) and shown on the appropriate charts.

7.2.1.3 Transition Level

7.2.1.3.1 States will make provision for the determination of the transition level to be used at any given time at each of their aerodromes.

7.2.1.3.2 Where two or more closely spaced aerodromes are located so that coordinated procedures and a common transition altitude are required, a common transition level will also be used at those aerodromes.

7.2.1.3.3 Appropriate personnel will have available at all times the number of the flight level representing the current transition level for an aerodrome.

Note: The transition level is normally passed to aircraft in the approach and landing clearances.

7.2.1.4 References to Vertical Position

7.2.1.4.1 The vertical position of aircraft operating at or below the transition altitude shall be expressed in terms of altitude. Vertical position at or above the transition level shall be expressed in terms of flight levels. This terminology applies during:

(a) climb;

(b) en-route flight; and

(c) approach and landing (except as provided for in paragraph 7.2.4.3 below, “References to vertical positioning after approach clearance”).

Note: This does not preclude a pilot using a QFE setting for terrain clearance purposes during the final approach to the runway.

7.2.1.4.2 *Passing through the transition layer*

While passing through the transition layer, vertical position shall be expressed in terms of:

(a) flight levels when climbing; and

(b) altitude when descending.

7.2.2 Take-Off and Climb

A QNH altimeter setting shall be made available to aircraft in taxi clearances prior to take-off.

7.2.3 En-Route

7.2.3.1 When complying with the ‘rules of the air’ requirements, an aircraft shall be flown at altitudes or flight levels (as applicable) corresponding to the magnetic tracks shown in the table of cruising levels in respective ‘rules of the air’ requirements.

7.2.3.2 Terrain Clearance

7.2.3.2.1 QNH altimeter setting reports should be provided from sufficient locations to permit determination of terrain clearance with an acceptable degree of accuracy.

7.2.3.2.2 For areas where adequate QNH altimeter setting reports cannot be provided, the appropriate authorities shall provide the information required to determine the lowest flight level which will ensure adequate terrain clearance. This information shall be made available in the most usable form.

7.2.3.2.3 Appropriate services shall at all times have available the information required to determine the lowest flight level which will ensure adequate terrain clearance for specific routes or segments of routes. This information shall be made available for flight planning purposes and for transmission to aircraft in flight, on request.

7.2.4 Approach and Landing

7.2.4.1 The QNH altimeter setting will be made available to aircraft in approach clearances and in clearances to enter the traffic circuit.

7.2.4.2 A QFE altimeter setting, clearly identified as such, may be made available in approach and landing clearances. This may be available on request or on a regular basis, in accordance with local arrangements.

7.2.4.3 References to Vertical Positioning after Approach Clearance

After approach clearance has been issued and the descent to land is begun, the vertical positioning of an aircraft above the transition level may be by reference to altitudes (QNH) provided that level flight above the transition altitude is not indicated or anticipated.

Note: This applies primarily to turbine engine aircraft for which an uninterrupted descent from a high altitude is desirable and to aerodromes equipped to control such aircraft by reference to altitudes throughout the descent.

7.2.5 Missed Approach

The relevant parts of paragraphs 7.2.2, "Take-Off and Climb", 7.2.3, "En-Route", and 7.2.4, "Approach and Landing" shall apply in the event of a missed approach.

Table 1 Flight level numbers

Flight level number	*Height in standard atmosphere*		*Flight level number*	*Height in standard atmosphere*	
	Metres	*Feet*		*Metres*	*Feet*
10	300	1 000	50	1 500	500
15	450	1 500	.. …	.. …	.. …
20	600	2 000	100	3 050	10 000
25	750	2 500	.. …	.. …	.. …
30	900	3 000	150	4 550	15 000
35	1 050	3 500	.. …	.. …	.. …
40	1 200	4 000	200	6 100	20 000
45	1 350	4 500	.. …	.. …	.. …
			500	12 250	50 000

Note: The heights shown in metres correspond to those in the table of cruising levels given in Appendix 3 to ICAO Annex 2 Rules of the Air.

7.3 Procedures for Operators and Pilots

7.3.1 Flight Planning

7.3.1.1 The levels at which a flight is to be conducted shall be specified in a flight plan:

(a) as flight levels if the flight is to be conducted at or above the transition level (or the lowest usable flight level, if applicable); and

(b) as altitudes if the flight is to be conducted at or below the transition altitude.

7.3.1.2 The altitudes or flight levels selected for flight:

(a) should ensure adequate terrain clearance at all points along the route;

(b) should satisfy air traffic control requirements; and

(c) should be compatible with the table of cruising levels in respective ‘rules of the air’ requirements, if relevant.

Note 1: The information required to determine the lowest altitude or flight level which ensures adequate terrain clearance may be obtained from the appropriate services unit (e.g., aeronautical information, air traffic or meteorological).

Note 2: The choice of altitudes or flight levels depends upon how accurately their vertical position relative to the terrain can be estimated. This in turn depends upon the type of meteorological information available. A lower altitude or flight level may be used with confidence when its position is based on current information which is relevant to the particular route to be flown and when it is known that amendments to this information will be available in flight. Refer to paragraph 7.3.4.2, “Terrain Clearance” below. A higher altitude or flight level will be used when based on information less relevant to the particular route to be flown and the time of the flight. The latter type of information may be provided in chart or table form and may be applicable to a large area and any period of time.

Note 3: Flights over level terrain may often be conducted at one altitude or flight level. On the other hand, flights over mountainous terrain may require several changes in altitudes or flight levels to account for changes in the elevation of the terrain. The use of several altitudes or flight levels may also be required to comply with air traffic services requirements.

7.3.2 Pre-Flight Operational Test

The following test should be carried out in an aircraft by flight crew members before flight. Flight crew members should be advised of the purpose of the test and the manner in which it should be carried out. They should also be given specific instructions on the action to be taken based on the test results.

(a) **QNH setting**

(1) With the aircraft at a known elevation on the aerodrome, set the altimeter pressure scale to the current QNH setting.

(2) Vibrate the instrument by tapping unless mechanical vibration is provided.

(3) A serviceable altimeter indicates the elevation of the point selected, plus the height of the altimeter above this point, within a tolerance of:

(i) ±20 m or 60 ft for altimeters with a test range of 0 to 9 000 m (0 to 30 000 ft); and

(ii) ±25 m or 80 ft for altimeters with a test range of 0 to 15 000 m (0 to 50 000 ft).

(b) **QFE setting**

(1) With the aircraft at a known elevation on the aerodrome, set altimeter pressure scale to the current QFE setting.

(2) Vibrate the instrument by tapping unless mechanical vibration is provided.

(3) A serviceable altimeter indicates the height of the altimeter in relation to the QFE reference point, within a tolerance of:

(i) ±20 m or 60 ft for altimeters with a test range of 0 to 9 000 m (0 to 30 000 ft); and

(ii) ±25 m or 80 ft for altimeters with a test range of 0 to 15 000 m (0 to 50 000 ft).

Note 1: If the altimeter does not indicate the reference elevation or height exactly but is within the specified tolerances, no adjustment of this indication should be made at any stage of a flight. Also, any error which was within tolerance on the ground should be ignored by the pilot during flight.

Note 2: The tolerance of 20 m or 60 ft for altimeters with a test range of 0 to 9 000 m (0 to 30 000 ft) is considered acceptable for aerodromes having elevations up to 1 100 m (3 500 ft) (Standard atmospheric pressure). Table 2 indicates the permissible range for aerodromes at different elevations when the atmospheric pressure at an aerodrome is lower than the standard, i.e., when the QNH setting is as low as 950 hPa.

Note 3: The tolerance of 25 m or 80 ft for altimeters with a test range of 0 to 15 000 m (0 to 50 000 ft) is considered acceptable for aerodromes having elevations up to 1 100 m (3 500 ft) (Standard atmospheric pressure). Table 3 indicates the permissible range for aerodromes at different elevations when the atmospheric pressure at an aerodrome is lower than the standard, i.e., when the QNH setting is as low as 950 hPa.

7.3.3 Take-Off and Climb

7.3.3.1 Before taking off, one altimeter shall be set on the latest QNH altimeter setting for the aerodrome.

7.3.3.2 During climb to, and while at the transition altitude, references to the vertical position of the aircraft in air ground communications shall be expressed in terms of altitudes.

7.3.3.3 On climbing through the transition altitude, the reference for the vertical position of the aircraft shall be changed from altitudes (QNH) to flight levels (1 013.2 hPa), and thereafter the vertical position shall be expressed in terms of flight levels.

7.3.4 En-Route

7.3.4.1 Vertical separation

7.3.4.1.1 During en-route flight at or below the transition altitude, an aircraft shall be flown at altitudes. References to the vertical position of the aircraft in air-ground communications shall be expressed in terms of altitudes.

7.3.4.1.2 During en-route flight at or above transition levels or the lowest usable flight level, whichever is applicable, an aircraft shall be flown at flight levels. References to the vertical position of the aircraft in air-ground communications shall be expressed in terms of flight levels.

7.3.4.2 Terrain Clearance

7.3.4.2.1 Where adequate QNH altimeter setting reports are available, the latest and most appropriate reports shall be used for assessing terrain clearance.

7.3.4.2.2 Where the adequacy of terrain clearance cannot be assessed with an acceptable degree of accuracy by means of the QNH reports available or forecast lowest mean sea level pressure, other information shall be obtained for checking the adequacy of terrain clearance.

7.3.5 Approach and Landing

7.3.5.1 Before beginning the initial approach to an aerodrome, the number of the transition level shall be obtained.

Note: The transition level is normally obtained from the appropriate air traffic services unit.

7.3.5.2 Before descending below the transition level, the latest QNH altimeter setting for the aerodrome shall be obtained.

Note: The latest QNH altimeter setting for the aerodrome is normally obtained from the appropriate air traffic services unit.

7.3.5.3 As the aircraft descends through the transition level, the reference for the vertical position of the aircraft shall be changed from flight levels (1 013.2 hPa) to altitudes (QNH). From this point on, the vertical position of the aircraft shall be expressed in terms of altitudes.

Note: This does not preclude a pilot using a QFE setting for terrain clearance purposes during the final approach to the runway in accordance with paragraph 7.3.5.4 below.

7.3.5.4 When an aircraft which has been given a clearance as number one to land is completing its approach using QFE, the vertical position of the aircraft shall be expressed in terms of the height above the aerodrome datum which was used in establishing obstacle clearance height (OCH) (Refer to PANS-OPS, Volume I, Part II Flight Procedure Requirements, Section 5. Approach procedures, Chapter 5. Final approach, 1.6, "Obstacle clearance altitude/height (OCA/H)"). All subsequent references to vertical position shall be made in terms of height.

Table 2 Tolerance range for altimeters with a test range of 0 to 9 000 m (0 to 30 000 ft)

Elevation of the aerodrome (metres)	*Permissible range*	*Elevation of the aerodrome (feet)*	*Permissible range*
600	581.5 to 618.5		1 940 to 2 060
900	878.5 to 921.5	3 000	2 930 to 3 070
1 200	1 177 to 1 223	4 000	3 925 to 4 075
1 500	1 475.5 to 1524.5	5 000	4 920 to 5 080
1 850	1 824 to 1876	6 000	5 915 to 6 085
2 150	2 121 to 2 179	7 000	6 905 to 7 095
2 450	2 418 to 2 482	8 000	7 895 to 8 105
2 750	2 715 to 2 785	9 000	8 885 to 9 115
3 050	3 012 to 3088	10 000	9 875 to 10 125
3 350	3 309 to 3 391	11 000	10 865 to 11 135
3 650	3 606 to 3 694	12 000	11 855 to 11 135
3 950	3 903 to 3997	13 000	12 845 to 13 155
4 250	4 199.5 to 4 300.5	14 000	13 835 to 14 165
4 550	4 496.5 to 4 603.5	15 000	14 825 to 15 175

Table 3 Tolerance range for altimeters with a test range of 0 to 15 000 m (0 to 50 000 ft)

Elevation of the aerodrome (metres)	*Permissible range*	*Elevation of the aerodrome (feet)*	*Permissible range*
600	569.5 to 630.5	2 000	1 900 to 2 100
900	868 to 932	3 000	2 895 to 3 105
1 200	1 165 to 1 235	4 000	3 885 to 4 115
1 500	1 462 to 1 538	5 000	4 875 to 5 125
1 850	1 809 to 1891	6 000	5 865 to 6 135
2 150	2 106 to 2 194	7 000	6 855 to 7 145
2 450	2 403 to 2 497	8 000	7 845 to 8 155
2 750	2 699.5 to 2 800.5	9 000	8 835 to 9 165
3 050	2 996.5 to 3 103.5	10 000	9 825 to 10 175
3 350	3 293.5 to 3 406.5	11 000	10 815 to 11 185
3 650	3 590.5 to 3 709.5	12 000	11 805 to 12 195
3 950	3 887.5 to 4 012.5	13 000	12 795 to 13 205
4 250	4 184.5 to 4 315.5	14 000	13 785 to 14 215
4 550	4 481.5 to 4 618.5	15 000	14 775 to 15 225

7.4 Altimeter Corrections

Note: This paragraph deals with altimeter corrections for pressure, temperature and, where appropriate, wind and terrain effects. The pilot is responsible for these corrections, except when under vectoring. In that case, the controller issues clearances such that the prescribed obstacle clearance will exist at all times, taking the cold temperature correction into account.

7.4.1 Responsibility

7.4.1.1 Pilot's responsibility

The pilot-in-command is responsible for the safety of the operation and the safety of the aeroplane and of all persons on board during flight time. This includes responsibility for obstacle clearance, except when an IFR flight is being vectored.

Note 1: Refer to Flight Operations Directive – Flight Operations, paragraph 7.5 Duties of Pilot-In-Command and adopted EASA implementing regulations, CAT.GEN.MPA.105 Responsibilities of the commander.

Note 2: When an IFR flight is being vectored, air traffic control (ATC) may assign minimum vectoring altitudes which are below the minimum sector altitude. Minimum vectoring altitudes provide obstacle clearance at all times until the aircraft reaches the point where the pilot will resume own navigation. The pilot-in-command should closely monitor the aircraft's position with reference to pilot-interpreted navigation aids to minimize the amount of navigation assistance required and to alleviate the consequences resulting from a failure of the ATS surveillance system. The pilot-in-command should also continuously monitor communications with ATC while being vectored and should immediately climb the aircraft to the minimum sector altitude if ATC does not issue further instructions within a suitable interval, or if a communications failure occurs.

7.4.1.2 Operator's Responsibility

The operator is responsible for establishing minimum flight altitudes, which may not be less than those established by States that are flown over. The operator is responsible for specifying a method for determining these minimum altitudes. This method shall be approved by the Authority and also the probable effects of certain factors shall be taken into account.

Note: Refer to Flight Operations Directive – Flight Operations, paragraph 7.2.7 Minimum Flight Altitudes and adopted EASA implementing regulations, CAT.OP.MPA.145 Establishment of minimum flight altitudes.

7.4.1.3 State's Responsibility

States are responsible to publish "The criteria used to determine minimum flight altitudes". in Section GEN 3.3.5 of their Aeronautical Information Publication (AIP). If nothing is published, it should be assumed that no corrections have been applied by the State.

Note 1: The content of Aeronautical Information Publication (AIP) is specified in Appendix 2 to ICAO Doc 10066 Procedures for Air Navigation Services Aeronautical Information Management (PANS-AIM).

Note 2: The determination of lowest usable flight levels by air traffic control units within controlled airspace does not relieve the pilot-in-command of the responsibility for ensuring that adequate terrain clearance exists, except when an IFR flight is being vectored.

7.4.1.4 Air Traffic Control (ATC)

If an aircraft is cleared by ATC to an altitude which the pilot-in-command finds unacceptable due to low temperature, then the pilot-in-command should request a higher altitude. If such a request is not received, ATC will consider that the clearance has been accepted and will be complied with. Refer to the applicable 'rules of the air' requirements and ICAO Doc 4444 Procedures for Air Navigation Services, Air Traffic Management (PANS-ATM), Chapter 6 Separation in the Vicinity of Aerodromes.

7.4.1.5 Flights Outside Controlled Airspace

7.4.1.5.1 For IFR flights outside controlled airspace, including flights operating below the lower limit of controlled airspace, the determination of the lowest usable flight level is the responsibility of the pilot-in-command. Current or forecast QNH and temperature values should be taken into account.

7.4.1.5.2 It is possible that altimeter corrections below controlled airspace may accumulate to the point where the aircraft's position may impinge on a flight level or assigned altitude in controlled airspace. The pilot-in-command must then obtain clearance from the appropriate control agency.

7.4.2 Pressure Correction

7.4.2.1 Flight Levels

When flying at levels with the altimeter set to 1013.2 hPa, the minimum safe altitude must be corrected for deviations in pressure when the pressure is lower than the standard atmosphere (1013 hPa). An appropriate correction is 10 m (30 ft) per hPa below 1013 hPa. Alternatively, the correction can be obtained from standard correction graphs or tables supplied by the operator.

7.4.2.2 QNH/QFE

When using the QNH or QFE altimeter setting (giving altitude or height above QFE datum respectively), a pressure correction is not required.

7.4.3 Temperature Correction

7.4.3.1 Requirement for Temperature Correction

The calculated minimum safe altitudes/heights must be adjusted when the ambient temperature on the surface is much lower than that predicted by the standard atmosphere. In such conditions, an approximate correction is 4 per cent height increase for every 10°C below standard temperature as measured at the altimeter setting source. This is safe for all altimeter setting source altitudes for temperatures above –15°C.

7.4.3.2 Tabulated Corrections

For colder temperatures, a more accurate correction should be obtained from Tables 4 a) and 4 b). These tables are calculated for a sea level aerodrome. They are therefore conservative when applied at higher aerodromes. To calculate the corrections for specific aerodromes or altimeter setting sources above sea level, or for values not tabulated, refer to paragraph 7.4.3.3, "Corrections for specific conditions" below.

Note 1: The corrections have been rounded up to the next 5 m or 10 ft increment.

Note 2: Temperature values from the reporting station (normally the aerodrome) nearest to the position of the aircraft should be used.

7.4.3.3 Corrections for Specific Conditions

Tables 4 a) and 4 b) were calculated assuming a linear variation of temperature with height. They were based on the following equation, which may be used with the appropriate value of t_0, H, L_0 and H_{ss} to calculate temperature corrections for specific conditions. This equation produces results that are within 5 per cent of the accurate correction for altimeter setting sources up to 3 000 m (10 000 ft) and with minimum heights up to 1 500 m (5 000 ft) above that source.

$$\text{Correction} = H \times \left(\frac{15 - t_0}{273 + t_0 - 0.5 \times L_0 \times (H + H_{ss})}\right)$$

where:

H = minimum height above the altimeter setting source (setting source is normally the aerodrome unless otherwise specified)

$t_0 = t_{aerodrome} + L_0 \times h_{aerodrome}$ . . . aerodrome (or specified temperature reporting point) temperature adjusted to sea level

L_0 = 0.0065°C per m or 0.00198°C per ft

H_{ss} = altimeter setting source elevation

$t_{aerodrome}$ = aerodrome (or specified temperature reporting point) temperature

$h_{aerodrome}$ = aerodrome (or specified temperature reporting point) elevation

7.4.3.4 Accurate Corrections

7.4.3.4.1 For occasions when a more accurate temperature correction is required, this may be obtained from Equation 24 of the Engineering Sciences Data Unit (ESDU) publication, Performance, Volume 2, Item Number 77022. This assumes an off-standard atmosphere.

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$$\frac{-\Delta t_{std}}{L_0} \ln\left(\frac{1 + L_0 \times \Delta h_{PAirplane}}{t_0 + L_0 \times \Delta h_{PAerodrome}}\right)$$

where:

$\Delta h_{PAirplane}$ = aircraft height above aerodrome (pressure)

$\Delta h_{GAirplane}$ = aircraft height above aerodrome (geopotential)

Δt_{std} = temperature deviation from the International Standard Atmosphere (ISA) temperature

L_0 = standard temperature lapse rate with pressure altitude in the first layer (sea level to tropopause) of the ISA

t_0 = standard temperature at sea level

Note: Geopotential height includes a correction to account for the variation of g (average 9.8067 m sec²) with heights. However, the effect is negligible at the minimum altitudes considered for obstacle clearance: the difference between geometric height and geopotential height increases from zero at mean sea level to –59 ft at 36 000 ft.

7.4.3.4.2 The above equation cannot be solved directly in terms of $\Delta h_{GAirplane}$, and an iterative solution is required. This can be done with a simple computer or spreadsheet programme.

7.4.3.5 Assumption Regarding Temperature Lapse Rates

Both the above equations assume a constant off-standard temperature lapse rate. The actual lapse rate may vary considerably from the assumed standard, depending on latitude and time of year. However, the corrections derived from the linear approximation can be taken as a satisfactory estimate for general application at levels up to 4 000 m (12 000 ft). The correction from the accurate calculation is valid up to 11 000 m (36 000 ft).

Note 1: Where required for take-off performance calculations or wherever accurate corrections are required for non-standard (as opposed to off-standard) atmospheres, appropriate methods are given in ESDU Item 78012, Height relationships for non-standard atmospheres. This allows for non-standard temperature lapse rates and lapse rates defined in terms of either geopotential height or pressure height.

Note 2: Temperature values are those at the altimeter setting source (normally the aerodrome). En route, the setting source nearest to the position of the aircraft should be used.

7.4.3.6 Small Corrections

For practical operational use, it is appropriate to apply a temperature correction when the value of the correction exceeds 20 per cent of the associated minimum obstacle clearance (MOC).

7.4.4 Mountainous Areas — En-Route

The MOC over mountainous areas is normally applied during the design of routes and is stated in State aeronautical information publications. However, where no information is available, the margins in Tables 5 and 6 may be used when:

(a) the selected cruising altitude or flight level or one engine inoperative stabilizing altitude is at or close to the calculated minimum safe altitude; and

(b) the flight is within 19 km (10 NM) of terrain having a maximum elevation exceeding 900 m (3 000 ft).

7.4.5 Mountainous Terrain — Terminal Areas

7.4.5.1 The combination of strong winds and mountainous terrain can cause local changes in atmospheric pressure due to the Bernoulli effect. This occurs particularly when the wind direction is across mountain crests or ridges. It is not possible to make an exact calculation, but theoretical studies (CFD Norway, Report 109.1989) have indicated altimeter errors as shown in Tables 7 and 8. Although States may provide guidance, it is up to the pilot-in-command to evaluate whether the combination of terrain, wind strength and direction are such as to make a correction for wind necessary.

7.4.5.2 Corrections for wind speed should be applied in addition to the standard corrections for pressure and temperature, and ATC should be advised.

Table 4 a). Values to be added by the pilot to minimum promulgated heights/altitudes (m)

Aerodrome temperature (°C)	*Height above the elevation of the altimeter setting source (metres)*													
	60	90	120	150	180	210	240	270	300	450	600	900	1200	1500
0	5	5	10	10	10	15	15	15	20	25	35	50	70	85
-10	10	10	152	15	25	20	25	30	30	45	60	90	120	150
-20	10	15	20	25	25	30	35	40	45	65	85	130	170	215
-30	15	20	25	30	35	40	45	55	60	85	115	170	230	285
-40	15	25	30	40	45	50	60	65	75	110	145	220	290	365
-50	20	30	40	45	55	65	75	80	90	135	180	270	360	450

Table 4 b). Values to be added by the pilot to minimum promulgated heights/altitudes (ft)

Aerodrome temperature (°C)	*Height above the elevation of the altimeter setting source (feet)*													
	200	300	400	500	600	700	800	900	1 000	1 500	2 000	3 000	4 000	5 000
0	20	20	30	30	40	40	50	50	60	90	120	170	230	280
-10	20	30	40	50	60	70	80	90	100	150	200	290	390	490
-20	30	50	60	70	90	100	120	130	140	210	280	420	570	710
-30	40	60	80	100	120	140	150	170	190	280	380	570	760	950
-40	50	80	100	120	150	170	190	220	240	360	480	720	970	1 210
-50	60	90	120	150	180	210	240	270	300	450	590	890	1 190	1 500

Table 5 Margin in mountainous areas (SI units)

Terrain variation	*MOC*
Between 900 m and 1 500 m	450 m
Greater than 1 500 m	600 m

Table 6 Margin in mountainous areas (non-SI units)

Terrain variation	*MOC*
Between 3 000 ft and 5 000 ft	1 476 ft
Greater than 5 000 ft	1 969 ft

Table 7 Altimeter error due to wind speed (SI units)

Wind speed (km/h)	*Altimeter error (m)*
37	17
74	62
111	139
148	247

Table 8 Altimeter error due to wind speed (non-SI units)

Wind speed (kt)	*Altimeter error (ft)*
20	53
40	201
60	455
80	812

Note: The wind speed values were measured 30 m above aerodrome elevation.