EUROCONTROL Guidelines for Cold Temperature Corrections by ATS

DOCUMENT IDENTIFIER : EUROCONTROL-GUID-

Edition Number	**:**	**1.0**
Edition Date	**:**	**24.10.2014**
Status	**:**	**Released Issue**
Intended for	**:**	**General Public**
Category	**:**	**EUROCONTROL Guidelines**

DOCUMENT CHARACTERISTICS

TITLE		
EUROCONTROL Guidelines for Cold Temperature Corrections by ATS		
	Publications Reference:	GUID-
	ISBN Number:	
Document Identifier	**Edition Number:**	1.0
EUROCONTROL-GUID-	**Edition Date:**	24.10.2014

Abstract

When the temperature is lower than ISA an aircraft will be lower than indicated by the barometric altimeter. Consequently, there is a risk that the specified clearance above obstacle is no longer sufficient and the effect of the low temperature must be compensated. The most efficient means to mitigate this effect is to quantify the effect of the difference from ISA in form of a correction that should be added to the minimum flight altitudes/heights to ensure the appropriate clearance above obstacles and terrain. ATS Authorities are responsible to develop and establish the necessary corrections for the cold temperature effect on altimetry and provide the air traffic control the values for minimum flight altitudes/minimum vectoring to be used in cold temperature conditions.

Keywords		
Cold Temperate	Responsibility	Operator/Flight Crew
Corrections	Application	Air Traffic Controller
Clearance	ATS Authority	Minimum Flight Altitude
Obstacle/Terrain		

Contact Person(s)	Tel	Unit
Neculai Cojocariu Stefania Nikolova-Tsankova	+32 2 729 3735 +32 2 729 3828	NMD/OPL

STATUS, AUDIENCE AND ACCESSIBILITY

Status		Intended for		Accessible via	
Working Draft	☐	General Public	☑	Intranet	☐
Draft	☐	EUROCONTROL	☐	Extranet	☐
Proposed Issue	☐	Restricted	☐	Internet (www.eurocontrol.int)	☑
Released Issue	☑				

INTENTIONALLY LEFT BLANK

DOCUMENT APPROVAL

The following table identifies all management authorities who have successively approved the present issue of this document.

AUTHORITY	NAME AND SIGNATURE	DATE
NMD/OPL/PRO	Neculai COJOCARIU	
Head of Unit NMD/OPL	Razvan BUCUROIU	
Director Network Manager Directorate	Joseph SULTANA	

DOCUMENT CHANGE RECORD

The following table records the complete history of the successive editions of the present document.

EDITION NUMBER	EDITION DATE	REASON FOR CHANGE	PAGES AFFECTED
1.0	24.10.2014	Released issue	ALL

Publications
EUROCONTROL Headquarters
96 Rue de la Fusée
B-1130 BRUSSELS

Tel: +32 (0)2 729 4715
Fax: +32 (0)2 729 5149
E-mail: publications@eurocontrol.int

CONTENTS

DOCUMENT CHARACTERISTICS 2

DOCUMENT APPROVAL 4

DOCUMENT CHANGE RECORD 5

CONTENTS 6

EXECUTIVE SUMMARY 7

1. Introduction 9
- 1.1 Purpose of the document 9
- 1.2 Scope of the document 9
- 1.3 Structure of the document 9
- 1.4 Abbreviations 9
- 1.5 Reference material 9

2. Requirements for Temperature Corrections 11
- 2.1 General 11
- 2.2 ICAO Provisions 12
  - 2.2.1 ICAO Recommended Correction Methods 13
  - 2.2.2 Responsibilities for the application of Cold Temperature Correction 14
    - 2.2.2.1 ATS authorities 14
    - 2.2.2.2 Operator/Flight Crew 15
    - 2.2.2.3 Air Traffic Controller 15

3. Application of Cold Temperature Corrections 16
- 3.1 ATS Authority 16
  - 3.1.1 Determination of minimum flight altitudes 16
  - 3.1.2 Determination of Temperature Corrections 16
  - 3.1.3 Publication of Temperature Corrections in AIPs 17
- 3.2 Air Traffic Controller 18
- 3.3 Operator 19
- 3.4 Flight Crew 19

ANNEX A – Instructions to use the Cold Temperature Correction Tool 20
- A.1 General 20
  - A.1.1 Table 1 – Specific Corrections 20
  - A.1.2 Table 2 – Specific Corrections 21
  - A.1.3 Table 3 – Temperature Banding 22

EXECUTIVE SUMMARY

This document contains guidance for the ATS Authorities to develop and establish the necessary corrections for the cold temperature effect on altimetry, and a common set of methods to be used for providing the air traffic control with the minimum flight altitudes to be used when corrections for the cold temperature effect on altimetry is required.

It aims to provide a toolbox for ATS authorities and ATS providers to identify, customise and implement harmonised solutions for compensating the effect of low temperatures on altimetry.

It analyses various factors for determining and applying cold temperature corrections and explains the roles of different stakeholders in the process, based on available practices and requirements set forth in ICAO Standards and Recommended Practices and recognises but does not discuss the relation with the responsibilities for obstacle clearance.

The document is structured around a study of the general requirements for cold temperature corrections and relevant ICAO provisions. It elaborates a step-wise process for the practical application of the proposed methodology for cold temperature corrections and contains tabulated corrections for cold temperature effect.

1. Introduction

1.1 Purpose of the document

The purpose of this document is to provide guidance for the appropriate ATS authorities to:

- develop and establish a methodology for a consistent application of the corrections for the cold temperature effect on altimetry at the level of airspace design;
- determine the value for minimum vectoring altitude and surveillance altitudes needed to facilitate the application of cold temperature corrections by ATS.

It aims to provide a toolbox for ATS authorities and ATS providers to identify and implement harmonised solutions for compensating the effect of low temperatures on altimetry.

1.2 Scope of the document

The document analyses the various factors for determining and applying cold temperature corrections and explains the roles of different stakeholders in the process, based on available practices and requirements set forth in ICAO Standards and Recommended Practices. The scope is limited to methodology for application of cold temperature corrections recognising the strong link with responsibilities for obstacle clearance.

1.3 Structure of the document

The "Guidelines for Cold Temperature Corrections by ATS" contain three Chapters and an Annex as follows:

Chapter 1 – introduces the purpose and the scope of the document.

Chapter 2 – analyses the general requirements for cold temperature corrections and relevant ICAO provisions.

Chapter 3 – provides the process for the practical application of cold temperature corrections.

Annex A – contains tabulated corrections for cold temperature effect

Note: The electronic version of the tables including the formulas for calculating the corrections are an indispensable part of these Guidelines available at this link: xxxxxxxxxxxxxxxxx

1.4 Abbreviations

1.5 Reference material

Part	Reference Material
Chapter 2	ICAO Annex 11 ICAO Doc 8168 – PANS-OPS Volume 1 – *Flight Procedures,* Part I, Section 4, Chapter 1, paragraph 1.7.5 ICAO Doc 8168 PANS-OPS, Volume I, Part II, Section 4, Chapter 1, paragraph 1.4.1 ICAO Doc 8168 PANS OPS Volume I, Part III, Section 1, Chapter 4

	ICAO Doc 4444, paragraph 8.6.5.2
Chapter 3	ICAO Annex 6, Part 1, 4.2.7.1, 4.2.7.2. and 4.2.7.4 ICAO Annex 15, Appendix 1 PANS-ATM, paragraphs 8.6.5.2 and 3.1.2

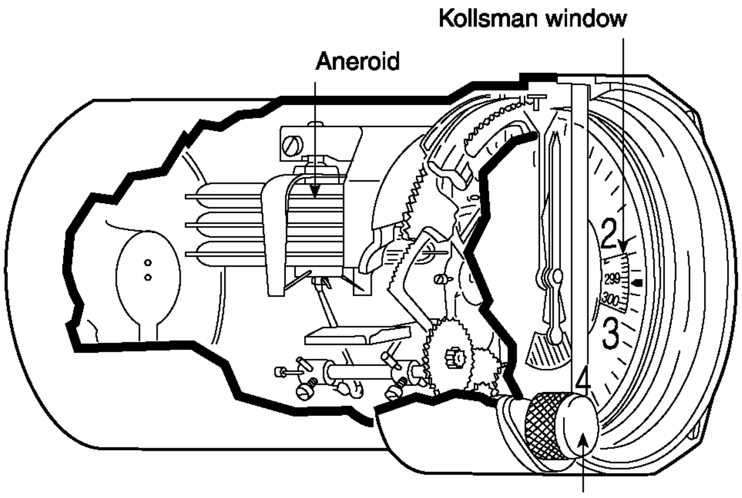
2. Requirements for Temperature Corrections

2.1 General

The altitude of an aircraft is determined based on the measurement of atmospheric pressure: the greater the altitude - the lower the pressure. When a barometer is supplied with a nonlinear calibration so as to indicate altitude, the instrument is called a pressure altimeter or barometric altimeter.

An aneroid barometer measures the atmospheric pressure from a static port outside the aircraft. Air pressure decreases with an increase of altitude—approximately 100 hPa per 800 meters or one inch of mercury per 1000 feet near sea level.

The aneroid altimeter is calibrated to show the pressure directly as an altitude above mean sea level, in accordance with a mathematical model defined by the International Standard Atmosphere (ISA). A barometric altimeter is a device that uses the static pressure to indicate the vertical distance from the pressure reference datum. Depending on the pressure reference datum used: 1013.2 hPa, QNH or QFE, a barometric altimeter will indicate Flight Level, Altitude or Height, accordingly.



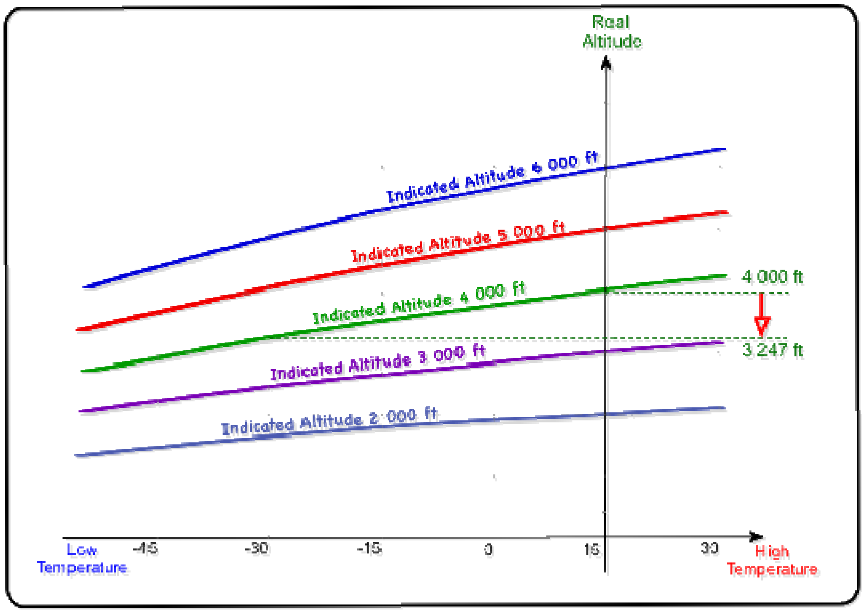
Note: Modern aircraft use pressure sensors and computerised algorithms to indicate altitude on electronic flight deck displays.

The temperature effect on the measurement made by a barometric altimeter can be explained as follows. When the atmosphere is below the temperature for which the altimeter has been calibrated, the molecules of the air lose energy and gravity is able to pull them closer to the earth. Consequently, the density and pressure of the air decrease more rapidly with height. When the atmosphere is warmed to a temperature above that for which the altimeter has been calibrated, the air molecules gain energy and can counter the force of gravity and the change in density and pressure with height is less.

If the altimeter is used under the two conditions it will experience for the same true height change a greater pressure change under the cold conditions than it will under the hot conditions. Since it converts pressure change into height change, the altimeter will register a greater height under the cold conditions than it will under the hot conditions even though the actual height ascended is the same. Consequently, the higher the altitude to be corrected, the larger the value for the correction.

For an accurate assessment of any temperature correction required, the difference from ISA temperature over the whole range of altitudes from the altimeter setting source to the true altitude of the altimeter would be needed. The corrections calculated on the temperature of the aerodrome (known as the altimeter setting source) are over-compensating the effect on altimetry, in the sense that the value for the correction is larger than the minimum needed to ensure compliance with the minimum obstacle clearance criteria

Pressure altimeters are calibrated to International Standard Atmosphere (ISA) conditions. Any deviation from ISA will result in an error proportional to the ISA deviation and to the height of the aircraft above the pressure reference datum.



Note: The diagram shows the relation between the indicated altitude and the temperature variation from ISA.

As it can be observed in the diagram, when the temperature is lower than ISA, an aircraft will be lower than indicated by the barometric altimeter. Alternatively, when the temperature is higher than ISA, the aircraft will be higher than what the baro-altimeter indicates.

Temperatures lower than ISA have an immediate effect on calculating that the appropriate clearance above obstacles exists. The most efficient means to mitigate this effect is to quantify the effect of the difference from ISA in form of an extra correction that should be added to the minimum flight altitudes/heights to ensure the appropriate clearance above obstacles and terrain.

2.2 ICAO Provisions

The effect of the temperatures lower than ISA is addressed by ICAO provisions, specific requirements being articulated for the ATS authorities, aircraft operators, flight crew and ATC to ensure that the required safe clearance above terrain and obstacles exists at all times. It must be emphasized that all corrections are necessary to ensure that the minimum obstacle clearance is not compromised.

The requirement to apply temperature correction to minimum altitudes is expressed in different places and in various forms in the *Procedures for Air Navigation Services – Aircraft Operations* (PANS-OPS, Doc 8168), Volume 1 – *Flight Procedures,* Part I, Section 4, Chapter 1:

a) In the context of vertical path control on non-precision approach procedures, § 1.7.5 states that "*In all cases, regardless of the flight technique used [author's note: continuous descent final approach, constant angle descent or stepdown descent], a temperature correction shall be applied to all minimum altitudes to control the vertical path of an aircraft on a non-precision approach procedure*".

b) The criteria for approach operations using of Baro-VNAV equipment must take into account the temperature constraints for the design of the obstacle clearance throughout approach and landing phase down to DA/H (§ 1.8.2).

c) Although not directly expressed as a requirement, the temperature correction to minimum altitudes is addressed by having to consider the pressure altimeter error in the design of DA/H for precision approaches (Figure I-4-1-2).

2.2.1 ICAO Recommended Correction Methods

As mentioned in previous paragraphs, the calculated minimum flight altitudes/heights must be adjusted when the ambient temperature on the surface is much lower than that predicted by the standard atmosphere.

In accordance with ICAO Doc 8168, PANS-OPS, it is considered appropriate for practical operational use to apply a temperature correction when the value of the correction exceeds 20[1] per cent of the associated minimum obstacle clearance (MOC). The 20 per cent value represents 200 to 400 feet (depending on the required MOC) that can be used in operations to accommodate small deviations from the range of temperatures for which the corrections where calculated.

ICAO Doc 8168, PANS–OPS, Volume I, provides a number of methods that can be used in specific conditions:

i. 4% 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;

ii. when the temperature measured at the altimeter setting source is lower than – 15°C, the required correction should be obtained from applying the formula below. The formula produces results that are within 5% of the accurate correction for altimeter setting sources up to 10 000 ft and with minimum heights up to 5 000 ft above that source.

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

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	=	0.00198°C / 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

iii. when more accurate corrections are required, Equation 24 of the Engineering Data Unit (ESDU) publication, Performance, Volume 2, Item Number 77022 could be applied.

$$\Delta h_{correction} = \Delta hP_{Airplane} - \Delta hG_{Airplane} = (-\Delta T_{std}/Lo)\mathbf{ln}[1 + Lo\ \Delta hP_{Airplane} / (To + Lo.hP_{Aerodrome})]$$

where:

ΔhPAirplane	=	Aircraft height above aerodrome (pressure)
ΔhGAirplane	=	Aircraft height above aerodrome (geopotential)
ΔTstd	=	temperature deviation from the standard day (ISA) temperature
Lo	=	standard temperature lapse rate with pressure altitude in the first layer (sea level to tropopause) of the ISA
To	=	standard temperature at sea level

[1] The airspace designers considers 20 per cent rule necessary to provide the flexibility for small variations of temperature outside the range for which the corrections are calculated and incorporated into the minimum flight altitudes values provided to ATS.

IFALPA considers that a 20 per cent reduction of the minimum obstacle clearance is too large to apply temperature corrections and strongly recommends that the temperature correction is to be applied as soon as the value of correction is larger than 10 per cent of the associated minimum obstacle clearance.

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, time of the year and the real time local weather system. However, the corrections derived from the linear approximation (method ii above) can be taken as a satisfactory estimate for general application at levels up to 13 000 ft. The correction from the accurate calculation is valid up to 36 000 ft.

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 Engineering Sciences Data Unit (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 geo-potential height or pressure height.

Although PANS-OPS provides a very accurate formula for corrections that can be applied outside the range given by the assumptions for method ii, considering that the value resulting from the application of the formula would be rounded up to a value that can be used operationally, it is considered sufficient to apply method ii for the calculation of corrections to minimum vectoring altitudes[2] (minimum vectoring altitudes or surveillance minimum altitudes) provided to ATS.

To facilitate the use of method ii above by the ATS, an electronic table is made available, the use of which is described in Annex A.

2.2.2 Responsibilities for the application of Cold Temperature Correction

The responsibilities for the application of corrections for cold temperature effect are strongly interlinked with the responsibilities for terrain/obstacle clearance.

The objectives of the air traffic control service as prescribed in ICAO Annex 11 do not include prevention of collision with terrain; however, when providing an ATS surveillance service to an IFR flight, in cases documented in PANS-ATM 8.6.5.2[3], the controller shall issue clearances such that the prescribed obstacle clearance will exist at all times.

Since the altimetry correction for the cold temperature effect is necessary to ensure the required clearance above terrain and obstacles, the responsibility for such correction goes together with the responsibility for terrain/obstacle clearance.

2.2.2.1 ATS authorities

ICAO Annex 11, paragraph 2.22 stipulates that: "*Minimum flight altitudes shall be determined and promulgated by each Contracting State for each ATS route and control area over its territory. The minimum flight altitudes determined shall provide a minimum clearance above the controlling obstacle located within the areas concerned*".

---

[2] In cases where minimum vectoring altitudes are not established by the airspace designers and the controllers use (according to local procedures) a specific set of minimum flight altitudes (AMA, minimum flight level en route) or surveillance minimum altitudes when vectoring aircraft, the ATS authority should provide the corrected values for such set of minimum altitudes.

[3] ICAO Doc 4444, PANS-ATM, § 8.6.5.2:

"When vectoring an IFR flight and when giving an IFR flight a direct routing which takes the aircraft off an ATS route, the controller shall issue clearances such that the prescribed obstacle clearance will exist at all times until the aircraft reaches the point where the pilot will resume own navigation. When necessary, the relevant minimum vectoring altitude shall include a correction for low temperature effect.

Note 1.— When an IFR flight is being vectored, the pilot may be unable to determine the aircraft's exact position in respect to obstacles in this area and consequently the altitude which provides the required obstacle clearance. Detailed obstacle clearance criteria are contained in PANS-OPS (Doc 8168), Volumes I and II. See also 8.6.8.2.

Note 2.— It is the responsibility of the ATS authority to provide the controller with minimum altitudes corrected for temperature effect."

ATM Procedures Development Sub-Group of EUROCONTROL Network Operation Team considers that "the controller shall issue clearances such that the prescribed obstacle clearance will exist at all times until the aircraft reaches the point where the pilot will re-join the flight planned route, or a published ATS route or instrument procedure".

In addition, the ATS authority[4] is responsible for determining the minimum flight altitudes corrected for temperature effect. In practice, the ATS authority (for EU context see footnote 4) will provide either the values or the methodology to be used by the ATS provider to determine the above mentioned values. The ATS provider must put in place specific arrangements to ensure that the determined values are available to the controller.

2.2.2.2 Operator/Flight Crew

The flight crew is responsible for any necessary cold temperature corrections to all published minimum altitudes/heights including the altitudes/heights for the initial and intermediate segment(s); the DA/H; and subsequent missed approach altitudes/heights, except for APV/BARO-VNAV approach procedures. In accordance with ICAO Doc 8168, PANS-OPS, Volume I, Part II, Section 4, Chapter 1, § 1.4.1, the final approach path vertical path angle (VPA) is safeguarded against the effects of low temperature by the design of the procedure.

Furthermore, 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 (ICAO 8168, PANS-OPS, Part III, Section 1, Chapter 4).

In this context it should be noted that Part III, Section 1, Chapter 4 deals with altimeter corrections for pressure, temperature and, where appropriate, wind and terrain effects. The pilot is responsible for these corrections, except for the temperature correction when being vectored by ATC or issued a direct routing as documented in ICAO Doc 4444, PANS-ATM, § 8.6.5.2 (*see footnote 3*).

The ATC rules and procedures described in this document do not suggest relieving pilots of their responsibility to ensure that any clearances issued by air traffic control units are safe in respect of terrain clearance.

2.2.2.3 Air Traffic Controller

In cases documented in ICAO Doc 4444, § 8.6.5.2 (*see footnote 3*) a controller must issue level clearances at or above the minimum vectoring altitudes (*see footnote 2*) corrected for cold temperature effect. The minimum vectoring altitudes and correction method will be determined by the ATS Authority. In case the ATS Authority provides only the methodology to determine the corrected values, the ATS provider must put in place a specific arrangement so as to ensure that the determined values will be provided to the controller.

4 ICAO Annexes define Appropriate ATS Authority as "the relevant authority designated by the State responsible for providing air traffic services." This Authority might be the State or suitable Agency. With the entry into force of the EU legislation on the single European sky, the EASA competence extension to ATM/ANS and the related principle of separation of service provision from supervision, the term "authority" is used thereto to *define national authorities in EU Member States which do not provide ATS*. For these cases, in these Guidelines the term "ATS authority" is meant to denote a part of a State's civil aviation administration, which could be either the National Supervisory Authority as defined by the SES legislation, national competent authority as referred by the EASA Basic Regulation (Regulation (EC) 216/2008) or any other competent national aviation authority as relevant.

3. Application of Cold Temperature Corrections

3.1 ATS Authority

In accordance with Annex 15, Appendix 1 (Contents of Aeronautical Information Publication), States should publish in Section GEN 3.3.5, "*The criteria used to determine minimum flight altitudes*". If nothing is published, it should be assumed that no corrections have been applied by the State[5].

Considering that, in ECAC airspace, most of the States are experiencing temperatures that require correction for minimum flight altitudes, it is recommended that such information is not omitted, and in case of no cold temperature correction applied, a clear statement to that effect is made in AIP GEN 3.3.5.

3.1.1 Determination of minimum flight altitudes

In accordance with ICAO Annex 11, 2.22, "*Minimum flight altitudes shall be determined and promulgated by each Contracting State for each ATS route and control area over its territory. The minimum flight altitudes determined shall provide a minimum clearance above the controlling obstacle located within the areas concerned*." These minimum flight altitudes can be of different types such as Area Minimum Altitude (AMA), Minimum Obstacle Clearance Altitude (MOCA), and Minimum Sector Altitude (MSA). In addition, Terminal Arrival Altitudes should be established for any RNAV procedures.

Furthermore, in accordance with ICAO Annex 15 – *Aeronautical Information Services*, the criteria used in the determination of minimum flight altitudes shall be published in the AIP, GEN 3.3.5. So shall e.g. a minimum obstacle clearance altitude (MOCA) be determined and published for each segment of the route. In mountainous areas, the MOC shall be increased and identified by the State and promulgated in the AIP

3.1.2 Determination of Temperature Corrections

When designing the structure of airspace where air traffic control is provided, an ATS authority will have to consider annual and seasonal variation of temperature when establishing the minimum flight altitudes.

The analysis of recorded meteorological data will be the basis for considering how the effect of cold temperatures should be mitigated in operations. Such an activity will indicate the magnitude of the correction required to operate within a given temperature range.

According to the airspace requirements and the surrounding environment, an airspace designer may consider a lower temperature as a reference for establishing the minimum flight altitudes.

The combination of concept of operations, airspace requirements and temperature range will indicate which of the following approaches would be appropriate for a given environment:

[5] ICAO Annex 6 recommends that the State of the operator should approve the method by which the operator is determining minimum flight altitudes (see paragraph 3.2 below). In so doing, the State should only approve such method after careful consideration of the probable effect of a number of factors including, *inter alia,* the inaccuracies in the indications of the altimeter used (ICAO Annex 6, Part 1, 4.2.7.4).

i. *Annual*

In areas where the temperatures recorded are not too low, and the seasonal variation is minor, it would be possible to calculate the cold temperature correction in accordance with historical meteorological data and publish the resulting minimum levels accordingly in the AIP. All minimum altitudes should then include the cold temperature correction which would be known to pilots.

It could be that some isolated higher obstacles will be subject to special arrangements (providing a protection around the obstacle rather than raising overall the minimum flight altitudes).

This approach has the benefit of having one set of values for minimum vectoring altitudes (*see footnote 2*) applicable for the entire year.

ii. *Seasonal*

The low temperatures are normally recorded within a defined period of the year. When the low temperatures experienced are significantly low during this season, the buffer necessary to accommodate an annual application of cold temperature correction may lead to a less efficient use of the airspace. In such cases the appropriate ATS authorities may consider a dual set of minimum flight altitudes: one applicable during "warm season" and one during the "cold season". The activation of one or the other set of values can be indicated in the State's AIP such as: "from 1 December to 31 March the cold temperature values for minimum flight altitudes are applied".

The set of values for minimum vectoring altitudes (*see footnote 2*) a controller must use in cases documented in ICAO Doc 4444, PANS-ATM, § 8.6.5.2 (*see footnote 3*) would be provided/activated accordingly.

iii. *Daily*

The cold temperature corrections can also be updated on a daily basis using the coldest temperature forecast for the day as the baseline. The supervisor will use the table/methodology as provided by the appropriate ATS authority to ascertain the set of minimum vectoring altitudes (*see footnote 2*) a controller will use that day.

The State will publish in AIP that correction for low temperature effect are applied, when necessary, by ATC.

iv. *Tactical*

When full integration of the methodology for cold temperature correction in the ATS system is performed, the controller will be provided with the appropriate information on the CWP.

The State will publish in AIP that correction for low temperature effect are applied, when necessary, by ATC.

A common aspect for the first two solutions is that they will not cover temperatures lower than those in the selected range. Therefore, they should be supplemented with specific procedures for temperatures lower than those in the selected range.

3.1.3 Publication of Temperature Corrections in AIPs

For controlled airspace, the State has to publish in Section GEN 3.3.5, *"The criteria used to determine minimum flight altitudes"*. This could include information about method(s) used for the correction of low temperature effect and how it is published (e.g. *"published MSA/MVA contain a temperature correction down to -xx degrees C"*, or *"correction for low temperature effect is always* *taken into account in ATC clearances in cases documented in ICAO Doc 4444, PANS-ATM, § 8.6.5.2*").

If nothing is published in GEN 3.3.5, it should be assumed that temperature correction is not applied (ICAO Annex 15). In such cases, the pilot-in-command is not relieved of his/her responsibility to ensure that adequate terrain clearance exists.

3.2 Air Traffic Controller

In cases documented in ICAO Doc 4444, PANS-ATM, § 8.6.5.2, "the controller shall issue clearances such that the prescribed obstacle clearance will exist at all times. When necessary, the relevant minimum vectoring altitude shall include a correction for low temperature effect."

However, the individual air traffic controller should not be the entity deciding how and when to apply temperature correction.

The controller should be provided with the following, as determined by ATS Authority:

- corrected values of the minimum vectoring altitudes (*see footnote 2*) to be applied
- indication and/or instruction when corrected altitudes are to be applied.[6]

Note. - When a pilot-in-command is unable to comply with level clearance issued by the controller, the pilot must inform the controller and ask for a revised clearance.

It is recommended not to oblige a controller to transmit via voice communication the information about low temperature correction application, as integral part of level clearances or instructions. Such information should rather be properly published in State's AIP and indicated on the charts concerned.

When the correction to the minimum vectoring altitudes (*see footnote 2*) is intended to cover a range of cold temperatures, it is very likely that the correction applied by ATS is greater than that required or the correction calculated by the flight crew (also considering that the pilot could use the exact temperature deviation from ISA when available on board).

This over correction occurs whenever the actual temperature is higher than the lowest temperature within the cold temperature range applied. The amount of over correction increases proportionately as the actual temperature rises above the coldest temperature within the cold temperature range and is amplified as the height of the column of air under consideration increases.

This phenomenon has the potential, in some circumstances, of generating unstable approaches when aircraft are vectored to intercept the published glide path in a manner that provides pilots with insufficient time to adjust from the ATS temperature corrected minimum vectoring altitude (*see footnote 2*) to the pilot determined temperature corrected procedure altitude.

As ATS is required to complete a safety risk assessment on how a chosen temperature correction method interacts with published instrument procedure altitudes, as described in paragraph 3.1.2, the following should be considered when vectoring an aircraft to establish an instrument approach on final approach regardless of the type of instrument approach the pilot wishes to fly:

a) If the temperature corrected minimum vectoring altitude is equal to or lower than the published instrument procedure altitude at the Final Approach Fix (FAF), over correction will not occur;

b) If the temperature corrected minimum vectoring altitude is higher than the published instrument approach procedure altitude at the FAF, over correction will occur. In order to accommodate this over correction ATC must vector the aircraft to establish it on the instrument approach procedure with sufficient distance for the pilot to adjust for the over correction prior to crossing the FAF. Once established on the instrument approach procedure, and provided a clearance for approach was issued by the controller, the pilot

[6] MSAW/APM alerting should be consistent with those values and applicability. In general, this should be the case for any other use of QNH corrected Mode C as well.

can initiate the appropriate adjustment for over correction. If terrain or other factors prevent vectoring of aircraft in this manner, ATC should consider one or more of the following:

1) select a more tactical temperature correction method;
2) review and if possible, amend the minimum vectoring altitudes in the vicinity of the final approach;
3) review and if possible, relocate the FAF to position more distant from the threshold which in turn facilitates a higher instrument procedure altitude at the FAF; and
4) vector aircraft to commence the instrument approach procedure at the Initial Approach Fix, or if appropriate, the Intermediate Approach Fix, as the procedure altitude at these fixes will be higher than that at the FAF.

3.3 Operator

In accordance with ICAO Annex 6 Part I, 4.2.7.1, an operator shall be permitted to establish minimum flight altitudes for those routes flown for which minimum flight altitudes have been established by the State flown over or the responsible State, provided that they shall not be less than those established by that State.

Furthermore, in paragraph 4.2.7.2 of the same document above it is specified that: "*An operator shall specify the method by which it is intended to determine minimum flight altitudes for operations conducted over routes for which minimum flight altitudes have not been established by the State flown over or the responsible State, and shall include this method in the operations manual. The minimum flight altitudes determined in accordance with the above method shall not be lower than specified in Annex 2.*"

3.4 Flight Crew

Temperature values on which to decide the magnitude of the correction needed 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, or, when available in the aircraft, the pilot could use the temperature deviation from ISA at the actual level.

Note. – Flight crew will assess the corrections to altimetry to compensate the effect of cold temperatures either by applying 4% of the height when temperatures are not lower than - 15°C, or the corresponding values from the tables in ICAO Doc 8168, Volume I, Tables III-1-4-1 a) and III-1-4-1 b).

When providing ATS based on surveillance to IFR flights, in cases documented in ICAO Doc 4444, PANS-ATM, § 8.6.5.2 (*see footnote 3)*, the controller is responsible for issuing clearances such that the prescribed obstacle clearance, and implicitly the application of the necessary temperature correction, will exist at all times. However, if the pilot-in-command finds the altitude unacceptable due to low temperature, then the pilot-in-command should request a higher altitude."

In the absence of such a request, the controller will consider that the clearance has been accepted and will be complied with.

In cases of conducting non-precisions approaches where the pilot-in-command considers that the level clearance received would not allow appropriate positioning for the geometric altitude to initiate the non-precision approach, he/she should inform ATC accordingly.

When cleared and established on the instrument approach procedure, or part thereof, the pilot-in-command is responsible for applying the appropriate correction for the cold temperature effect.

ANNEX A – Instructions to use the Cold Temperature Correction Tool

A.1 General

The electronic tool (Excel Workbook) provided together with these guidelines is intended to assist airspace designers and ATS authorities, in general, to assess how temperature correction can be most effectively accommodated in the airspace design, to identify which temperature ranges would provide the most efficient utilization of a given volume of airspace.

The tool provides three spreadsheets where the user may calculate the value of the correction required for a given set of parameters, the possibility to calculate the effect of the cold temperature on the minimum vectoring altitude and the possibility to assess a the correction for temperature banding.

A.1.1 Table 1 – Specific Corrections

Specific Correction				
Aerodrome Elevation:	700			
Aerodrome Temperature:	-40	Specific Correction (Modified formula):	2471	ft
MSA/SMA/MVA:	11000			
NB:				
1- The above uses a modified formula to that provided in DOC 8168 at Part III, Section 1, Chapter 4, Paragraph 4.3.3				
2- Enter values into green coloured cells				
3- The result is provided in the yellow coloured cell and is rounds up to the nearest foot.				

A.1.2 Table 2 – Specific Corrections

Accurate																
CWTC Required after:	200															
Aerodrome Elevation:	1000															
	MSA/SMA/MVA															
Temperature	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000	7500	8000
15	3	0	-3	-7	-10	-14	-17	-21	-24	-28	-31	-35	-38	-42	-46	-49
14	2	0	-2	-3	-5	-7	-9	-10	-12	-14	-16	-17	-19	-21	-23	-24
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	-2	0	2	4	5	7	9	11	13	14	16	18	20	22	24	26
11	-4	0	4	7	11	14	18	21	25	29	32	36	40	43	47	51
10	-5	0	5	11	16	21	27	32	38	43	49	54	60	65	71	76
9	-7	0	7	14	21	29	36	43	50	58	65	72	80	87	94	102
8	-9	0	9	18	27	36	45	54	63	72	81	91	100	109	118	128
7	-11	0	11	22	32	43	54	65	76	87	98	109	120	131	143	154
6	-13	0	13	25	38	51	63	76	89	102	115	128	141	154	167	180
5	-14	0	14	29	43	58	73	87	102	117	131	146	161	176	191	206
4	-16	0	16	33	49	65	82	98	115	132	148	165	182	199	216	233
3	-18	0	18	36	55	73	91	110	128	147	165	184	203	222	241	260
2	-20	0	20	40	60	80	101	121	142	162	183	203	224	245	266	287
1	-22	0	22	44	66	88	110	133	155	177	200	223	245	268	291	314
0	-24	0	24	48	72	96	120	144	168	193	217	242	267	291	316	341
-1	-26	0	26	52	77	103	130	156	182	208	235	262	288	315	342	369
-2	-28	0	28	55	83	111	139	167	196	224	253	281	310	339	368	397
-3	-30	0	30	59	89	119	149	179	210	240	270	301	332	363	394	425
-4	-31	0	32	63	95	127	159	191	224	256	288	321	354	387	420	453
-5	-33	0	34	67	101	135	169	203	238	272	307	341	376	411	446	481
-6	-35	0	36	71	107	143	179	215	252	288	325	362	398	435	473	510
-7	-37	0	38	75	113	151	189	227	266	304	343	382	421	460	499	539
-8	-39	0	40	79	119	159	199	240	280	321	362	403	444	485	526	568
-9	-41	0	42	83	125	167	210	252	295	337	380	423	467	510	554	597
-10	-44	0	44	88	132	176	220	265	309	354	399	444	490	535	581	627
-11	-46	0	46	92	138	184	231	277	324	371	418	465	513	561	609	657
-12	-48	0	48	96	144	192	241	290	339	388	437	487	536	586	636	687

A.1.3 Table 3 – Temperature Banding

Temperature banding	
Aerodrome Elevation:	26
mperature banding interval:	15
CWTC Required after:	200
Unacceptable Max dif:	200

				MSA 1					MSA 2					MSA 3				
				MSA/SMA/MVA: 1600					MSA/SMA/MVA: 2000					MSA/SMA/MVA: 3000				
	Temperature bands			**Low temp**	**High - Low**	**Correction**	**New**	**Max**	**Low temp**	**High - Low**	**Correction**	**New**	**Max**	**Low temp**	**High - Low**	**Correction**	**New**	**Max**
	High		**Low**	**Correction**	**Temp Diff.**	**Rounded up**	**MSA**	**Diff**	**Correction**	**Temp Diff.**	**Rounded up**	**MSA**	**Diff**	**Correction**	**Temp Diff.**	**Rounded up**	**MSA**	**Diff**
Start temperature :	15	to	0	87	87	100	1700	100	109	109	200	2200	200	165	165	200	3200	201
Temperature bands:	-1	to	-16	191	98	200	1800	107	240	123	300	2300	183	362	186	400	3400	224
	-17	to	-32	309	111	400	2000	202	388	139	400	2400	152	586	211	600	3600	225
	-33	to	-48	443	127	500	2100	184	557	159	600	2600	202	843	241	900	3900	299
	-49	to	-64	599	147	600	2200	148	753	184	800	2800	232	1139	279	1200	4200	340
	-65	to	-80	781	171	800	2400	191	981	215	1000	3000	234	1486	326	1500	4500	341
	-81	to	-96	995	202	1000	2600	207	1251	255	1300	3300	304	1895	386	1900	4900	391
	-97	to	-112	1253	243	1300	2900	290	1575	306	1600	3600	330	2388	465	2400	5400	476
	-113	to	-128	1568	297	1600	3200	329	1972	374	2000	4000	402	2992	570	3000	6000	578
	-129	to	-144	1963	372	2000	3600	410	2469	469	2500	4500	500	3749	715	3800	6800	766
	-145	to	-160	2470	480	2500	4100	509	3109	605	3200	5200	696	4726	923	4800	7800	997
	-161	to	-176	3148	641	3200	4800	693	3965	809	4000	6000	845	6036	1239	6100	9100	1303
	-177	to	-192	4099	901	4100	5700	902	5166	1139	5200	7200	1172	7882	1749	7900	10900	1767

NB:

1- The above uses a modifed forumla to that provided in DOC 8168 at Part III, Section 1, Chapter 4, Paragraph 4.3.3