CONSIDERING TEMPERATURE CORRECTIONS FOR AIR TRAFFIC SERVICE

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Abstract. This article covers one of the most relevant topics during seasonal (autumn-winter) navigation flights that is temperature correction while handling air traffic. In the article, the authors make analysis of relevant up-to date federal and international rules and regulations, they present main notions and terms, also justify the application aspects of temperature correction. Moreover, they introduce the way of determining temperature correction for handling air traffic with the perspective of using that data in relation to MSAW function.

Keywords: temperature correction, minimum altitude, safe altitude/height, true altitude/height, obstacle clearance, obstacle clearance area.

The introduction of a new airspace structure (NASS) in the Moscow zone of the Unified System of Air Traffic Management (MZ US ATM) at the beginning of December 2020 was largely revolutionary, not evolutionary, which is very atypical for the development of complex systems, and still leads to revision of applicable procedures and rules. For the implementation of NASS, the Federal Aviation Flight Rules in the Airspace of the Russian Federation (FAFR AS RF 136/42/51) were cancelled, the Federal Rules for the Use of Airspace (FR UAS 138) were changed, which updated not only the flight rules using altitudes in feet, but also the rules for calculating the safe flight altitudes of an aircraft (AC), which define a new way of taking into account temperature corrections. At the same time, by the order of the Ministry of Transport of the Russian Federation dated October 31, 2014 No. No. 305 for NASS implementation, the procedure for the development and rules for the provision of aeronautical information were approved, referring mainly to the documents of the International Civil Aviation Organization (ICAO), including the Rules for Air Navigation Services. Aircraft Flight Operations" (Doc 8168) regarding the development of maneuvering patterns and procedures. ICAO, in contrast to the experience of Russia before NASS implementation, has differences in the issue of taking into account temperature corrections to barometric altimeter readings. Thus, the previously analyzed and clarified issue [1] required rethinking in the context of new conditions. That is why it is proposed to be further understood by the main participants of the air navigation services (ANS) process, mainly air traffic controllers, in order to improve the quality of ANS, including upon receipt of relevant requests from pilots during the autumn-winter period.

Significant portion of the information about the need to take into account the effects of low temperatures is contained in Doc 8168. The need for corrections is due to the fact that pressure altimeters are calibrated to indicate **true** altitude under international standard atmosphere (ISA) conditions. Any deviation from ISA will therefore result in an erroneous reading on the altimeter. If the temperature is higher than ISA, then the **true** altitude will be higher than the figure indicated by the altimeter. Similarly, the **true** altitude will be lower when the temperature is lower than ISA. The altimeter error may be significant in extremely cold temperatures [2].

Thus, we can conclude that the true and "barometric" vertical distances almost always differ from each other. And it explains, among other things, one of the reasons why aircraft gain altitude better in winter than in summer.

For a correct understanding of the application of the temperature correction, it is necessary to understand the basic terms (heights/altitudes) published in the AIP RF and dispersed in regulatory documents:

Altitude/height – vertical distance from the level taken as the reference point to the given point. **Altitude** is measured from the mean sea level (geoid), **height** - from the selected level, **true altitude** - from the terrain level at the reference point [3];

safe flight altitude – flight altitude, excluding the collision of the aircraft with the ground (water) surface or obstacles on it [3]; or - **the minimum allowable** flight altitude of the aircraft, which guarantees against collision with the ground (water) surface or obstacles on it [4];

MZV – minimum clearance above the highest obstacle [5] (true clearance decreases under the influence of low temperatures and requires correction of barometric altitude);

MOC – minimum obstacle clearance [2] (corresponds to the MZV in Annex 2 to the FR UAS);

MOCA – minimum obstacle clearance altitude [2] (on the route/procedure leg/section);

MNM – minimum [6] (published in AIP RF on route legs/sections similarly to MOCA);

MSA – minimum sector altitude [2] (does not include correction for minimum temperature in ICAO);

MSAAT/MSHAT – minimum **safe flight** altitude/height in the terminal area (**TMA**) (**air hub area**) [5, 6] (includes a minimum temperature correction for a particular aerodrome);

OCA/OCH – obstacle clearance altitude/height [2] (relative to which the operational minima and the minimum descent altitude/height are determined);

SMAA – surveillance minimum altitude area [6] (on map 57 of section AD AIP, does not include correction for minimum temperature);

Now, the designated basic terms can be divided into areas of their application in situations described by the relevant rules.

Clause 3.34.1. [4], formed on the basis of ICAO documents and interpreted from the point of view of application, defines the basic conditions for account

ing for obstacles:

1) flying under instrument flight rules (**IFR**) only;
2) not below the published **minimum altitude** for flight on the airway (or the appropriate route, except for sections adjacent to the runway (RWY) where level flight is not presupposed);
3) outside the airways (appropriate routes) no closer than 8000 m from the obstacle and not lower than the **true** altitude of 300 m in flat and hilly areas or 600 m in mountainous areas.

It is worth noting that the term minimum altitude does not have a specific definition, but occurs in all the documents mentioned above in slightly different variations:

Minimum altitude/height [3, 6];

Minimum vectoring **altitude/height** [3];

Minimum radar vectoring **altitude** [2];

Minimum sector **altitude/height** [2, 3, 6];

Minimum flight **altitude** [3, 4];

Minimum obstacle clearance **altitude** [2, 4];

Minimum altitude [4, 6];

Minimum flight **altitude** according to IFR [4];

Minimum safe flight **altitude** [4];

Minimum safe **altitude/height** [4];

Minimum allowable flight **altitude/height** [4];

Minimum safe flight **altitude** in the aerodrome area (air hub area) [5, 6];

Minimum safe flight **altitude** in the area formed by the lines of parallels and meridians of the cartographic grid [5].

The above examples of variations have a common phrase - the **minimum altitude**, which, after analyzing the context of the applied rules, leads us to the conclusion that it is necessary to understand a single entity, with differences only in:

- an obstacle accounting zone (a certain width of a route section or area when flying off-route);
- the required minimum obstacle clearance;

- the need to take into account the temperature correction;
- the person responsible for the correction accounting.

Summing up the intermediate result after analyzing the presented facts, we can make the following conclusions:

1. all indicated "minimum altitudes" are related only to the safe passage of obstacles on route sections / in areas, that is, not at procedural and route waypoints;
2. safety is primarily determined by the minimum **true** obstacle clearance (MZV or MOC) affected by temperature, which at low temperatures **requires a barometric altitude correction**;
3. of all the “minimum altitudes”, only MSAAT/MSHAT (and the circle of flights) includes a temperature correction for the minimum air temperature near the ground at the aerodrome published on the corresponding maps for a period of at least 5 years [5];
4. the responsible person shall, where appropriate, take into account the temperature correction for the actual ground air temperature at the aerodrome.

An analysis of national [3, 4, 5, 6] and international [2] regulatory documents on the distribution of responsibility for taking into account the temperature correction shows that it all comes down to three situations:

1. the pilot, when flying on published routes, after receiving an air traffic control altitude clearance, may request from the controller to maintain a higher altitude, adjusted according to the internal rules of the operator (airline), which may affect separation and must be taken into account by the controller;
2. the pilot, when flying in class G airspace under IFR (for example, after getting into instrument weather conditions) at minimum altitude less than 300-500 feet from the border with class C, requests from the LCU controller clearance to climb the corrected altitude and leave the uncontrolled airspace;
3. when vectoring or straightening under the conditions of using the air traffic service (ATS) surveillance system, including at the request of the pilot, the controller must provide the flight not lower than the surveillance minimum

altitudes (SMA Areas), which must be corrected due to the influence of low temperatures.

The need for temperature correction during vectoring can also be justified by the probability of activation of airborne ground proximity warning systems due to insufficiency of the MOC, which will induce aircraft to pull up immediately and climb steeply to avoid hazardous terrain, possibly compromising separation between aircraft [7].

Thus, it remains to find the optimal way to determine the temperature correction by the ATC unit, after formalization of which it becomes possible to take into account the minimum safe altitude warning function (MSAW) in the corresponding algorithms when flying outside the published routes.

According to the documents [2, 3, 5], the temperature correction of the altimeter is determined by formulas (1), (2) and (3):

formula (1)

$$\Delta \mathrm{Ht} = \mathrm{H} \times \left(\frac{15 - \mathrm{t0}}{273 + \mathrm{t0} - 0{,}5 \times \mathrm{L0} \times (\mathrm{H} + \mathrm{H}ss)}\right)$$

formula (2)

$$\mathrm{t0} = \mathrm{ta} + \mathrm{L0} \times \mathrm{Hss}$$

formula (3)

$$\mathrm{ALT} = \mathrm{H} + \mathrm{Hss}$$

where:

ΔHt – temperature correction in feet (ft);

H – height above the altimeter setting source in feet (ft);

ALT – altitude in feet (ft);

t0 – aerodrome temperature adjusted to mean sea level in degrees Celsius (°C);

ta – aerodrome temperature (on the ground) in degrees Celsius (°C);

L0 – ISA temperature gradient of 0.00198 °C per feet (°C/ft);

Hss – altimeter setting source elevation (the lowest RWY threshold) in feet (ft).

This formula does not reflect the practical needs of the ATS unit to determine the temperature correction. For practical use in QNH and foot altitude measurement conditions, it is required to find the temperature band at which altimeter temperature corrections for minimum altitudes will be applied in 100-foot increments, which corresponds to the minimum resolution of the RBS aircraft transponder altitude data transmission.

We express **ta** from formulas (1), (2) and (3):

formula (4)

$$ta = \frac{\Delta Ht \times 273 - \Delta Ht \times L0 \times Hss + \Delta Ht \times L0 \times 0{,}5 \times ALT + (ALT - Hss) \times 15 - (ALT - Hss) \times L0 \times Hss}{\Delta Ht + (ALT - Hss)} - L0 \times Hss$$

We substitute the required values into the obtained formula (4) and, by changes of ΔHt, determine temperature banding intervals for each hundred feet of temperature correction, the values are rounded up to integers and entered in Table 1, taking into account the minimum temperatures at the aerodrome according to long-term observations and the heights required for correction.

Table 1

Accounting for temperature corrections for minimum altitudes

Authors: Glukhov Y.E., Ganeev O.N. [8]

ALTITUDE	**+100'/+30m**	**+200'/+60m**	**+300'/+90m**	**+400'/+120m**	**+500'/+150m**
1800'/550m	+14 -8°C	-9 -27°C	-28 -44°C	-45 -58°C	-59 -71°C
1900'/580m	+14 -6°C	-7 -24°C	-25 -40°C	-41 -54°C	-55 -66°C
2000'/610m	+14 -5°C	-6 -22°C	-23 -37°C	-38 -50°C	-51 -62°C

Temperature correction calculator available by code

The obtained altimeter correction values in multiples of 100 feet are used by the ATS unit for the actual temperature at the aerodrome as a reference material and / or can be integrated into MSAW taking into account and displaying the actual corrected minimum altitudes. For example, according to Table 1, at the actual temperature at the aerodrome in band from -23°C to -37°C the minimum altitude of 2000 feet must be increased by 300 feet, i.e. the cleared altitude must not be lower than 2300 feet in the appropriate obstacle clearance zone.

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