BOB MAYNARD

Watch Out Below

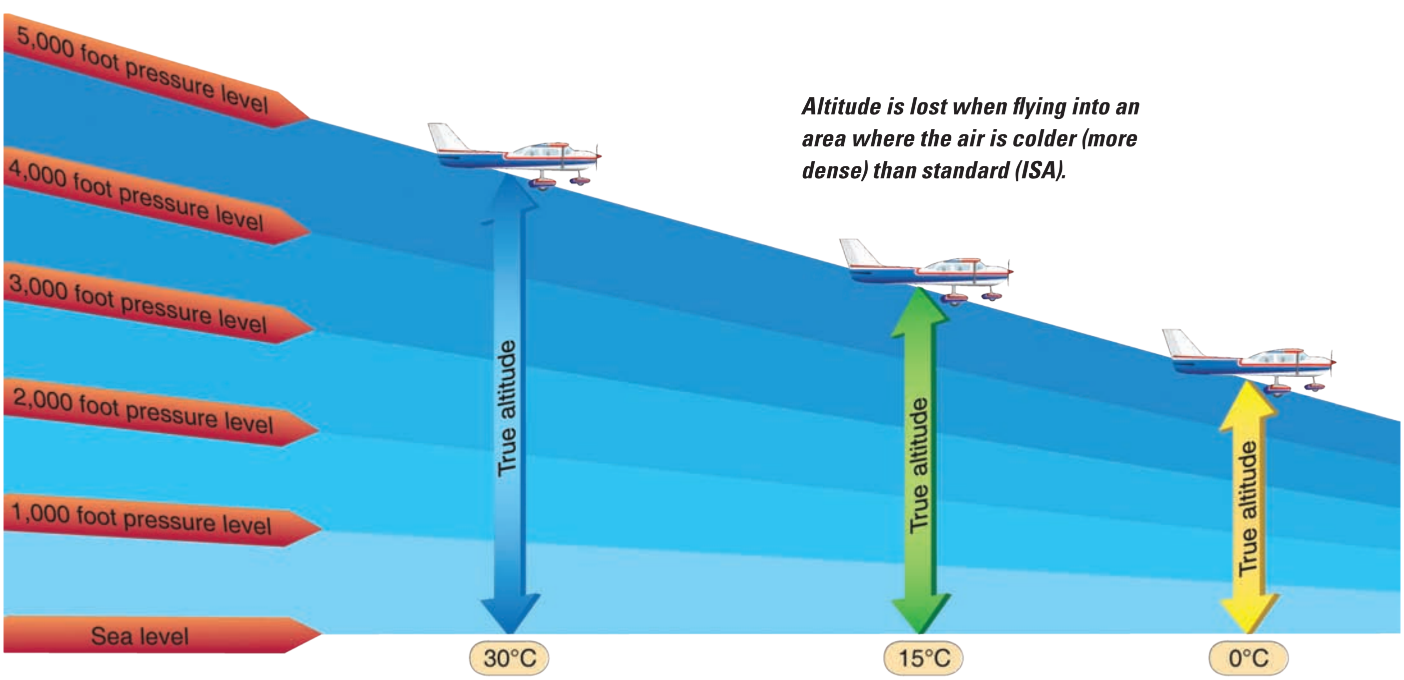
What's Your True Altitude?

Although this issue of *FAA Safety Briefing* bridges winter and the (hopefully) warmer days of spring, it's not uncommon for Mother Nature to retain her icy grip a bit longer than we'd like. Consequently, there's a long list of unique issues that should be considered before attempting any cold-weather flying. Some of the more obvious issues include runway contamination, icing conditions, strong winds aloft, fuel contamination from condensation, and the effects of extreme cold on aircraft instruments and engines. One of the more elusive issues, however, is underestimating the often hazardous difference between indicated altitude and true altitude.

A barometric altimeter only indicates correctly when the temperature is standard, which is commonly known as international standard atmosphere (ISA). ISA is 15 degrees Celsius (59 degrees Fahrenheit) at sea-level by international standards. Temperature decreases by approximately 2 degrees per 1,000 feet of altitude. At a sea-level airport, the only time that indicated altitude is equal to true altitude is when the surface temperature is 15 C. Anything lower than that temperature, your aircraft will be lower than indicated. Anything higher will result in your true altitude being higher than indicated. This can be seen from the illustration below.

Error, Error

In extremely cold conditions, the difference between indicated altitude and true altitude can be significant. The table on the right shows the possible altimeter errors based on the temperature and height above an airport.



Reported Temp °C	Height Above Airport in Feet													
	200	300	400	500	600	700	800	900	1,000	1,500	2,000	3,000	4,000	5,000
+10	10	10	10	10	20	20	20	20	20	30	40	60	80	90
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	130	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

ICAO Cold Temperature Error Table

Adjusting the Math

The adjustments for temperature compensation are currently handled by air traffic control (ATC) by changing the aircraft's minimum vectoring altitude. For example, at a cold-climate airport in the summer, ATC might vector you to the final approach course for an instrument approach at 1,500 feet mean sea level (MSL), whereas in the winter, they will most likely vector you to the final approach course at 2,000 feet MSL. This ensures that you will have adequate terrain clearance while being vectored to an instrument approach in very cold conditions. Some flight crews go one step further and intentionally adjust the decision altitude (DA) or minimum descent altitude (MDA) utilizing the error table to ensure adequate obstacle clearance at DA or MDA.

For a sea-level airport on a day when the temperature is -30 C with a "200-½" (200 feet above the ground and a half mile visibility) instrument landing system (ILS) approach, the adjustment made to the DA would be to add 40 feet to the published DA. Therefore the decision to go around would be made when the barometric altimeter reading is at 240 feet instead of 200 feet. The effect of this adjustment is that the missed approach would actually be made at 200 feet true altitude — as the FAA intended — as opposed to a pilot making no adjustment and actually initiating the missed approach at 160 feet true altitude.

The ILS system has worked well for years since the geometry of the ILS radio signal is unaffected by temperature. A three-degree ILS glideslope will always be a three-degree vertical path regardless of the temperature.

Approach with Caution

The *Aeronautical Information Manual* (AIM) states: "When operating in extreme cold temperatures, pilots may wish to compensate for the reduction in terrain clearance by adding a cold temperature correction." Unfortunately, with the introduction of barometric vertical navigation (baro-VNAV) GPS approaches, simultaneous updating of the temperature compensation procedures did not happen.

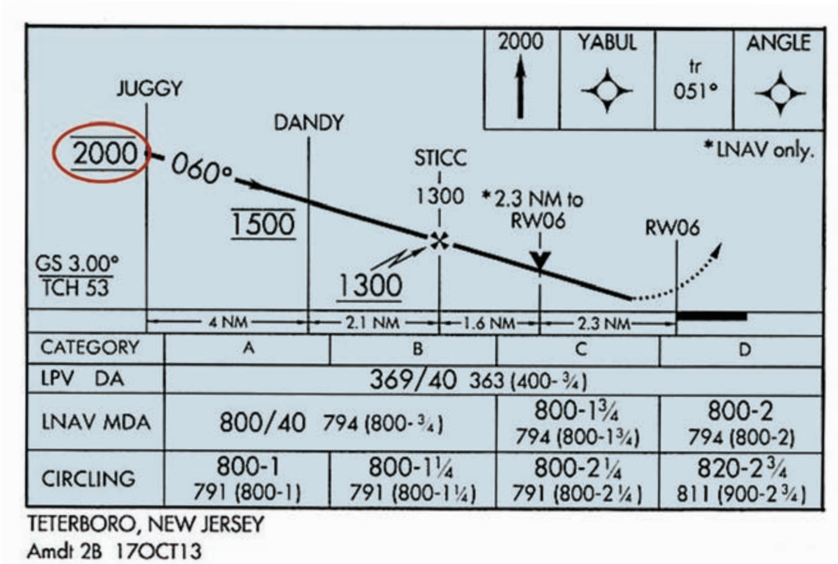
Many of the flight management systems connect theoretical points in space without regard to temperature, which means that as the temperature gets lower, the vertical path gets more and more shallow. In fact, the reason for the minimum temperature restriction on most of the baro-VNAV approaches is to limit the shallowness of the vertical path angle. The only way to correct that path angle using baro-VNAV is to recalculate the crossing altitudes using the correct temperature compensation. This way, your aircraft will cross the final approach fix (FAF) at the correct true altitude, and the vertical path will once again be the angle that the FAA intended.

A pilot has no authority to cross the final approach fix below the published minimum crossing altitude, which means temperature compensation for ISA plus conditions is not allowed at this time.

There is no specific FAA guidance defining how to notify ATC of the pilot's intent to use temperature compensation or whether a pilot is authorized to use temperature compensation after being given a specific ATC clearance.

With the ability of the newer aircraft to automatically temperature compensate, altitude adjustments are becoming an increasingly sticky issue. The newest Honeywell flight management software allows a temperature compensation selection prior to approach that will automatically recalculate all of the intermediate crossing altitudes on the approach. This issue will require further FAA guidance before these types of conflicts become more and more commonplace.

If you are fortunate enough to have a Wide Area Augmentation System (WAAS) equipped GPS on your aircraft and have the ability to conduct local-



Be aware of temperature compensation communication between you and ATC. In this example, you have been cleared for the instrument approach shown here and expected to cross JUGGY at 2,000 feet. If the temperature that day is -30 C, the corrected altitude should be 2,380 feet according to the temperature error table. However, there are two problems with attempting this temperature correction. First, the approach chart clearly states that you are to cross at only 2,000 feet, not at-or-above. Second, with Newark departing to the north, Newark approach will probably not be happy with the lack of clearance that you have created between your aircraft and the departing Newark traffic.

izer performance with vertical guidance (LPV) approaches, the portion of the approach where the LPV vertical path is captured is fixed because the vertical path is based upon geometric altitude and not baro-VNAV. This still leaves the pilot responsible to correct for the DA, and it still does not resolve the issue of crossing altitudes of the intermediate and final approach fixes prior to intercepting the LPV final approach path. It is still up to the pilot to adjust for those segments of the approach.

Know the Variables

As you have noticed, there are also maximum temperature limits on many of the baro-VNAV approaches. Those limits are to prevent a path that is too steep. Theoretically you could temperature compensate for ISA within the allowed limits on the approach chart, but this presents an additional problem. On a day when the temperature is ISA plus 30 degrees, you might be tempted to compensate in the opposite direction to ensure that you would cross the FAF in the first example of the sea level ILS at 1,200 feet indicated altitude rather than the published altitude of 1,500 feet. That would put you at a true altitude of 1,500 feet as the FAA intended. However, you have no authority to cross the FAF below the published minimum crossing altitude, which means temperature compensation for ISA plus conditions is not allowed at this time.

With the very limited guidance on temperature compensation, you must be very careful if you attempt to use these procedures. At a minimum you must ensure the following:

1. Communicate with ATC and obtain permission to use temperature compensation on all segments of the approach (the DA or MDA may be adjusted without coordination).
2. Keep a copy of the ICAO Cold Temperature Error Table readily available so you can verify the calculations.
3. Thoroughly review the approach chart to ensure that you do not violate any crossing restrictions such as cross-at altitudes.
4. If your aircraft has automated temperature compensation within the navigation computer, ensure you are properly trained to use that feature.
5. Include the radar altimeter in your pilot/crew scan as a backup for any errors that might occur during temperature compensation calculations.
6. Always respect the ground proximity warning systems, and take immediate corrective action in the case of an alert or warning.

Cold weather flying can be very challenging. This particular aspect of navigation adds more variables and deserves the same scrutiny and pilot knowledge that de-icing or stopping distances pose. With proper training and coordination with ATC, temperature compensation calculations can be accomplished safely.

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Learn More

Instrument Flying Handbook, chapter 5
http://1.usa.gov/1gEbJfb

Aeronautical Information Manual (AIM), chapter 7
http://1.usa.gov/1a96lqq