STEVE KROG

COMMENTARY / THE CLASSIC INSTRUCTOR

Density Altitude

Why is it important to a safe pilot?

BY STEVE KROG

WE ARE ALL FAMILIAR with the term density altitude, or at least should know of it. But seldom do we take it seriously enough to actually take the time to calculate its effect on our flight on a warm day. Instead, one might think, "It's a bit warm and humid today. I guess it will take a little more runway to take off." That is about the extent of it for many pilots, unfortunately, when considering density altitude.

What exactly is density altitude? How does it affect aircraft performance?

And why should a pilot be concerned about it?

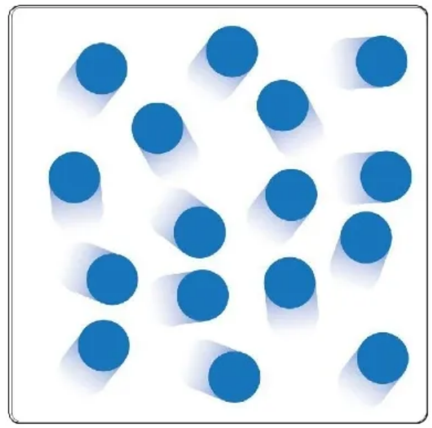
In the simplest of terms, density altitude is pressure altitude adjusted for nonstandard temperature. Pressure altitude can easily be found by setting your sensitive altimeter to 29.92 inches in the Kollsman window and then reading what the altimeter is indicating. Using that altitude and correcting it for the nonstandard temperature, we can find today's density altitude.

In today's flying environment, it is quite easy to acquire the density altitude because most all the airports that have automated surface observing system or automated weather observing system services include the density altitude at the end of each recorded briefing.

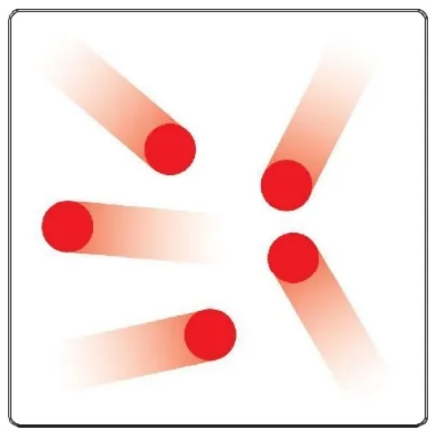
Understanding density altitude is important for many reasons. It affects engine, aircraft, and propeller performance. Combined, they can create an uncomfortable situation if the pilot has not taken this seriously into consideration.

Here in the relatively flat upper Midwest country, density altitude is mostly a nonfactor except in the summer months. It can fool many of us on a hot humid day. We are on average only about 1,000 feet above sea level. But then we'll have a stretch of 85-95 degree Fahrenheit days, usually around a holiday, when friends are in town and want an airplane ride. Let the fun begin.

The most simplistic analogy I have come up with when explaining density altitude to students is as follows. Assume for this discussion that at sea level and 59 degrees Fahrenheit every cubic foot has 100 molecules of air in it. The aircraft we are flying is a Piper J-3 Cub with an 85-hp Continental engine. The propeller is metal, 71 inches long with a 45-inch pitch, commonly referred to as a 7145. According to the manufacturer, the engine will deliver 85 hp when turning at 2575 rpm at sea level and 59 degrees Fahrenheit.



Cold Air



Hot Air

The higher the temperature, the less dense the air.

Let's assume the current temperature is 90 degrees Fahrenheit. Since the air is less dense, there are only 75 molecules of air in each cubic foot, but our aircraft needs to experience 100 molecules per cubic foot to perform as desired. Consequently, the airplane's performance will be significantly affected in this situation.

If the engine cannot get 100 molecules of air per cubic foot and is only getting 75 molecules per cubic foot, it will not be able to provide a full 85 hp. The fuel-to-air mixture generated by the carburetor will be on the rich side because of the lack of adequate air, further reducing horsepower. We may only be able to generate 70 hp. How does that affect everything else? Performance is reduced. If you have a fuel mixture control on your aircraft, it can and should be adjusted for density altitude.

Next, let's consider the propeller in simple terms. If it cannot get a full 85 hp delivered to it to obtain 2575 rpm, the rotation speed is slightly less. It can't move the aircraft forward 45 inches with every revolution (under ideal temperature and rpm settings). The aircraft is being pulled through the air at a slower-than-anticipated airspeed. To maintain a constant 60 mph climb, the pitch attitude will have to be lowered to a lesser angle. By lowering the nose, you will gain airspeed but now the rate of climb is reduced.

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If you try to maintain the usual climb pitch attitude, the airspeed will suffer and probably only show 50 mph. At this airspeed, you are in a nose-high attitude nearing the back side of the power curve, meaning you cannot climb due to the steepness of the nose. Now you are nose high, cannot climb, and possibly approaching the stall speed of the aircraft. This is where power-on stalls occur.

By lowering the nose to reestablish a 60 mph climb, you may soon find the airplane is only able to gain altitude at just a few feet per minute. Again, this is important to know and recognize if departing from a runway with obstructions of any kind at the departure end.

Aircraft performance is affected by all the above. If the airplane needs to have 100 molecules of air per cubic foot moving over and under the wing to generate enough lift for flight, the only way to provide that much airflow is to move faster through the less dense air. In a high-density altitude situation, your airspeed indicator may only be showing 40 mph when your true groundspeed is 50-55 mph in a no-wind condition. The same sensation can occur when landing with a high-density altitude.

Again, the airspeed may indicate a proper 60 mph on approach, but your groundspeed is somewhat to significantly greater.

High-density altitude significantly affects the performance of the aircraft systems and, therefore, the entire aircraft.

For example, let's use a common training aircraft that has a 2,300-pound gross weight at takeoff. The outside air temperature is 86 degrees Fahrenheit, the density altitude is 3,000 feet, the surface wind is light and variable, and the runway is turf.

Applying this data to the aircraft performance chart for calculating takeoff distance, the aircraft will need an estimated 1,185-foot ground roll. And to clear a 50-foot obstacle, the distance increases to about 2,115 feet. But these numbers apply to a hard surface runway.

Found in the fine print accompanying the performance chart, there is a statement that says, "For operation on a dry, grass runway, increase distances by 15 percent." Adding this figure, our takeoff roll now becomes 1,363 feet, and we'll need an estimated 2,432 feet to clear a 50-foot obstacle. But the turf hasn't been mowed in more than a week and is about 6 inches tall.

The turf runway we intend to use is 3,000 feet long and has high tension power lines on one end. If you intend to take off toward the power lines, you'll still have 568 feet of runway to spare without factoring in a safety margin for the taller grass. There is no true rule of thumb for operating in taller grass other than it will have some impact on the ground roll. A good, safe, and proficient pilot will usually add 15-20 percent to the ground roll to compensate for the taller grass. As a good, safe, and proficient pilot, would you proceed with the takeoff in this situation?

Surface winds are light, somewhat variable, and appear to be slightly favoring a departure toward the power lines. For safety, though, you decided to take off in the opposite direction to avoid the obstruction. After studying the surface wind, it appears you have an estimated 4 mph tailwind on takeoff. What does that add to the ground roll distance?

Once again, the fine print states, "For every 2.5 mph of tailwind, add 10 percent to the ground roll." In this example, you have an estimated 4 mph tailwind. For safety reasons, you should add 20 percent, giving a ground roll of 1,636 feet.

Are there any other factors a good pilot should consider before making the decision to depart? Consider this:

Many pilots I know will, after calculating the takeoff distance using the performance charts, also apply their own established rule and add it to the performance of the aircraft. Some add 10-15 percent to the calculated figures while others add 25-30 percent for a larger safety margin.

The published data found in the aircraft pilot's operating handbook (POH) was determined by using a brand-new aircraft — airframe, engine, and propeller. The aircraft you are using is nearly 40 years old, the engine has a little more than 1,000 hours since the last major overhaul, and the propeller has been reconditioned at least once. One can assume the empty weight of this aircraft is also quite different than a new airplane of the same make and model.

Many pilots I know will, after calculating the takeoff distance using the performance charts, also apply their own established rule and add it to the performance of the aircraft. Some add 10-15 percent to the calculated figures while others add 25-30 percent for a larger safety margin. Much depends on where you are doing most of your flying. If in the Midwest flatlands, 15 percent may be a good number. But if you're flying in hill country, 25-30 percent would be a much safer number to employ when calculating takeoff distances.

Neglecting to consider aircraft performance can cause an incident — or worse. An acquaintance of mine learned this lesson one day last summer when he made an early morning landing at his planned destination. He intended to depart for his home base in the early afternoon. Before taking the time to calculate the required runway, he assumed he could easily make it.

Thankfully, this individual was practicing the rule of picking a "no go" point on the runway. The first attempt was aborted at the "no go" point. Giving it some thought, he decided to try a short-field takeoff. That made little difference and was shut down again at the "no go" point. The third attempt was a combination of a turning move and a never-stopping blend of a short- and soft-field takeoff. Again, "no go."

At that point, my acquaintance made two smart decisions. First, he retrieved the POH and determined that the aircraft would never get airborne under the current conditions. And second, he parked the airplane and waited until early evening after the temperature had dropped and then made a safe departure.

There are small airports that, under certain conditions, allow you to land safely but will not have enough runway to allow for a safe takeoff. Take a moment and know what you're getting into before something unforeseen happens.

Keep flying and fly safely. *EAA*

Steve Krog, EAA 173799, has been flying for more than four decades and giving tailwheel instruction for nearly as long. In 2006 he launched Cub Air Flight, a flight training school using tailwheel aircraft for all primary training.