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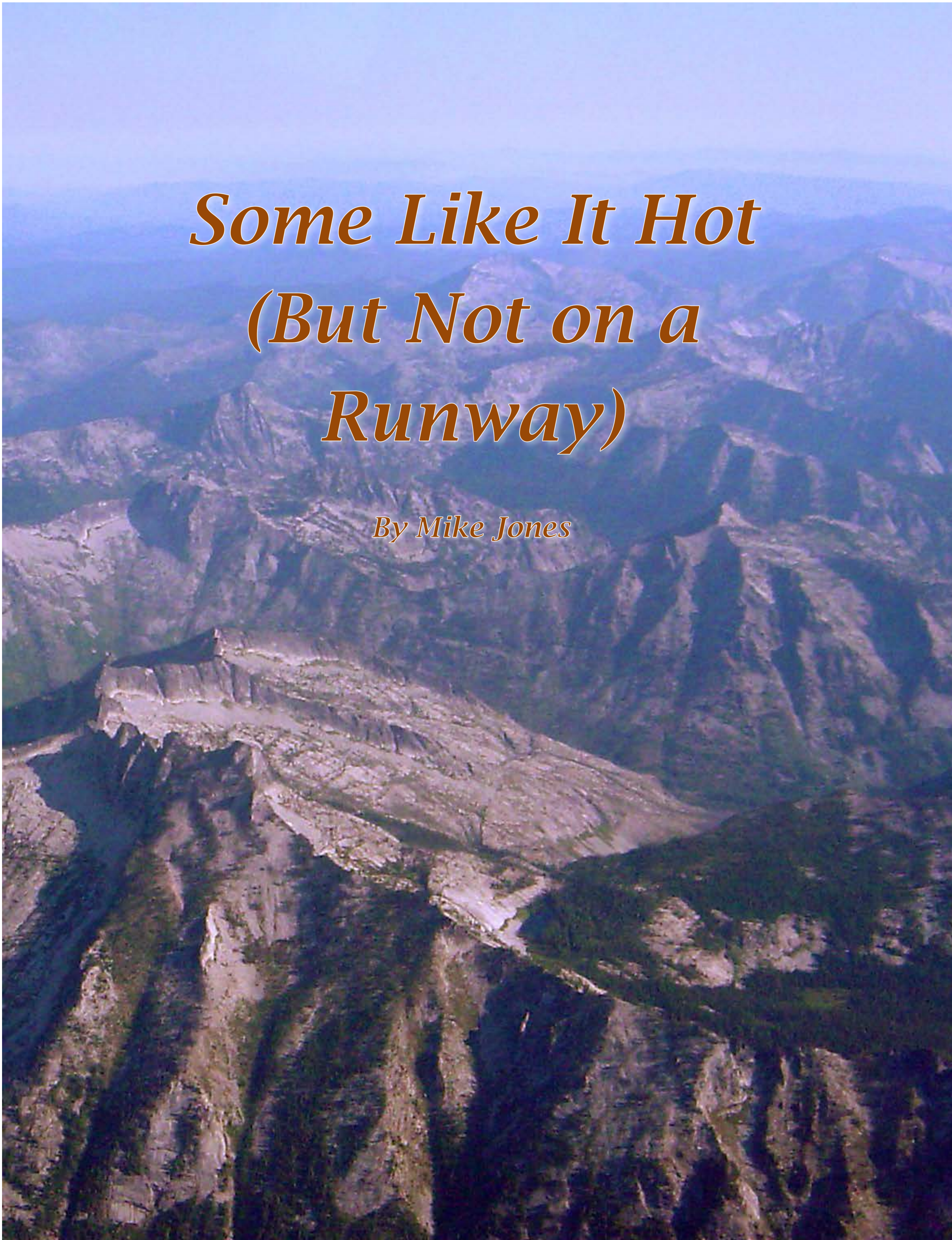
By Mike Jones



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Have I told you about the day I almost killed my favorite brother-in-law? It's an embarrassing story, but a good story. It even includes a moral for the grandkids.

Flunking the Real-World Test

Back when I was a new pilot 300-hour pilot — a most dangerous time, as everyone knows — my sainted wife and I flew commercially to the mountains to visit family. I may have mentioned my new aeronautical skills to my brother-in-law Gordon, who became excited about an airplane ride over the Rockies. Eager to oblige, early in the week I trundled down the mountain to the local airport where a flight school offered training in venerable Cessna 172s.

As I recall, the FBO was happy to empty my wallet. There was a general discussion of my flying experience, a written test on Cessna performance, and a check-ride with an instructor younger than the Skyhawk we flew. It was the proverbial piece of cake. My training was fresh, the runway was long, and the morning cool. I bought donuts for the family's breakfast on the way home.

Saturday arrived, a much different day, with steel-hard skies and scalding August temperatures. After lunch the whole family came down to the FBO, excited and chatty. I cautiously preflighted the plane and made sure four hours of fuel was on board. I carefully decided where everybody should sit: my brother-in-law is athletic and tall, his son was a strapping young man of maybe 150 pounds and my niece was a demure 100 pounds. We loaded up and called for our taxi clearance.

The airport was modern and well-equipped. The 5,000 foot runway was exactly at 3,937 feet ASL. There was a gentle crest about 3,000 feet down the centerline. The temperature had to be every bit of 90˚F (32˚C). I confidently ran through the final pre-take-off checklist. Carb heat off, mixture rich, throttle full, breaks released! And almost nothing happened.

Weary but loyal, the Skyhawk waddled unenthusiastically down the runway. The tires went thump, thump, thump over the cracked pavement. The engine was flaying, the noise deafening, and the plane was shaking — but the acceleration simply wasn't there. It took an eternity for the airspeed indicator to come alive. Hmmmm, I observed passively; this feels different.

The end of the runway began to fill the windscreen. Late in the game, I decided to become a pilot and not a passenger. I pushed the throttle harder, pushed the carb heat in again, pushed the mixture in again. Suddenly there was a tiny burst of power — a slight but pronounced additional kick. The airspeed touched 80 knots but we're still on the ground. Gordon looked over at me — is this normal, his eyes asked?

The wings finally decided to join the party. I gently, ever so gently, pulled back on the yoke. Tall weeds grabbed for the Goodyears. There was a line of telephone wires — the dreaded 50-foot obstacle. I vividly remember seeing the very last inch of concrete race beneath our wheels. We probably were 20 feet off the ground after rolling nearly a mile.

I had the good sense not to do anything drastic. My death-grip on the yoke kept us straight and level. Somehow we cleared the wires and slowly climbed. I started breathing again. Pretending everything was normal, we spent an hour gingerly sight-seeing in the mountains. Carefully, ever so gently, we returned to base and landed uneventfully.

Every word you just read is absolutely true. How many mistakes did you count?

SECTION 5
PERFORMANCE

CESSNA
MODEL 172S

SHORT FIELD TAKEOFF DISTANCE
AT 2550 POUNDS

CONDITIONS:

Flaps 10°
Full Throttle Prior to Brake Release
Paved, level, dry runway
Zero Wind
Lift Off: 51 KIAS
Speed at 50 Ft: 56 KIAS

Press Alt In Feet	0°C		10°C		20°C		30°C		40°C	
	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst	Grnd Roll Ft	Total Ft To Clear 50 Ft Obst
S. L.	860	1465	925	1575	995	1690	1070	1810	1150	1945
1000	940	1600	1010	1720	1090	1850	1170	1990	1260	2135
2000	1025	1755	1110	1890	1195	2035	1285	2190	1380	2355
3000	1125	1925	1215	2080	1310	2240	1410	2420	1515	2605
4000	1235	2120	1335	2295	1440	2480	1550	2685	1660	2880
5000	1355	2345	1465	2545	1585	2755	1705	2975	1825	3205
6000	1495	2605	1615	2830	1745	3075	1875	3320	2010	3585
7000	1645	2910	1785	3170	1920	3440	2065	3730	2215	4045
8000	1820	3265	1970	3575	2120	3880	2280	4225	2450	4615

NOTES:

1. Short field technique as specified in Section 4.
2. Prior to takeoff from fields above 3000 feet elevation, the mixture should be leaned to give maximum RPM in a full throttle, static runup.
3. Decrease distances 10% for each 9 knots headwind. For operation with tail winds up to 10 knots, increase distances by 10% for each 2 knots.
4. For operation on dry, grass runway, increase distances by 15% of the "ground roll" figure.

Density Rules

Let's go back to basics. Flying in the cold, clear, crisp days of winter is a joy. Cold air gets your blood racing because your almost-to-TBO puddle jumper is transmogrified into a piston-powered rocket ship. The engine drives harder; takeoffs are faster, climbs are steeper. You're grinning like Will Smith, roaring into the sky in an alien space ship yelling "I gotta get me one of these!" Winter flying is *muy macho*. It's thrilling.

Then Spring arrives and your winged steed becomes a lethargic flying potato.

The evil behind this phenomenon is *density altitude*. Aviation writer Rod Machado defines high altitude is any airport above 4,000 feet, and I think he meant high *density* altitude. I agree. For sea-level pilots flying from long smooth runways, density altitude is an annoyance. But when you are high or hot, density altitude can be a killer. If your local 'drome is reporting a density altitude at or above 4,000 feet — or even lower, if the runway is short, soft, or loaded with obstacles — get out your POH and do some careful reading. On the POH I included here, notice that in theory I should have been fine with a 3,730 foot take-off roll. But that was without adding any allowance for a tired old engine, nor for the fact the runway had an up-hill gradient. My bad!

All our Cessna planes are equipped with charts which show the expected performance of the airplane on a "standard day." A standard day is defined as a sea-level pressure setting of 29.92 inches at about 60˚F. Wander from those two conditions and your plane's performance changes faster than an angry girlfriend.

Two rules should be tattooed into our foreheads. Rule #1 is simple: High altitudes degrade airplane performance. Rule #2 is the big worry: when temperatures get high, things can get even worse, very fast.[1] Hot and high is the worst combination. Welcome to the test-pilot world of high density altitudes.

Density Altitude Dangers

FAR 91.116 "Pre-flight Action" offers the good advice that every pilot check the weather conditions likely to be expected, including the "aircraft performance

[1] There's one other factor worth mentioning: humidity. Humid air hurts performance as well because water vapor takes up the same volume as oxygen but doesn't help combustion. Less O_2 means you're getting less power from each cylinder. Our POH pages don't include an adjustment for humidity because most of the time the change is far less important than the two other factors.

under expected values of airport elevation and runway slope, aircraft gross weight, and wind and temperature." High DA situations demand every ounce of performance your plane can produce. If you don't do the math you simply won't know how bad things can get, very quickly. Watch for these changes:

- Power. High DAs degrade your engine. The thin air reduces engine efficiency because you're either running lean and generating less power or running too rich, semi-flooding the engine.

- Propeller. High DAs degrade the efficiency of the propeller. This causes slower acceleration and longer take-off rolls. Be ready.

Photo 1: A typical AWOS at a G.A. Airport

- Wings. High DAs reduce the efficiency of the wing. Plan on longer take-off rolls and greatly reduced rates of climb. In extreme cases you could simply run out of runway. I almost did.

High density altitudes also sap the airplane's performance during landings. Hot, thin air won't move the airspeed needle so your airspeeds will be unexpectedly low. To get 70 knots on short final you will need more power and a higher groundspeed. Those extra knots will increase your landing roll, put more wear on brakes and tires, and maybe cause a runway excursion. Your passengers will be unimpressed.

For those of you — like me — who smugly fly perched behind a turbocharger, that helpful device is not a cure-all.

Yes, the turbocharger can help the engine compensate for the reduction in air density. But there's no turbocharger for the prop or the wings. Performance still suffers.

Just for the record, density altitude affects everybody. I sat on a Delta jet in Phoenix one long summer day after the crew computed it simply was too hot to get the Boeing off the ground with the runway available. They off-loaded thousands of pounds of fuel and we departed safely, only to stop at a cooler intermediate airport to load the fuel back on.

My friend Jim Wiltjer was a Pan Am captain, flying heavily-loaded, under-powered Boeings across the Atlantic. He tells a story about one departure from Paris on a high DA summer day. At max power, the plane rolled down the runway *for 120 seconds*. As the 707 finally clawed its way into the smoggy Paris air and was barely sustaining a positive rate of climb, the French ATC controller radioed them. "Pan Am 123," he said, "Three miles ahead is the Eiffel Tower. Please don't hit it!"

Yep, everybody worries about density altitude. Or they should.

How Many Mistakes?

Let's come back to my adventurous Saturday afternoon in the Rockies. I count at least ten mistakes:

1. Sloppy FBO Check-out: Amazingly, nobody during the check-out said a word about density altitude and I never thought to ask.

2. Wrong Time of Day. We flew in the afternoon because it was convenient, but a cool morning would have been much safer.

3. Too Heavy. My brother-in-law invited his kids. With those passengers and myself, that's about 650 pounds of family. Far too much for a C-172 on a hot summer day.

4. Really Really Too Heavy. I topped off the tanks, as always. Not a problem at sea level, but potentially catastrophic at high density altitudes.

5. Didn't Do the Math. The density altitude should have been top of my mind. I didn't record the pressure altitude but let's assume it was 4,000 feet. With an outside temperature of 32˚C the density altitude was about 7,000 feet. How exciting!

6. Didn't Look in the POH. In retrospect, the Cessna 172 POH suggests this adventure required 2,065 feet of runway and 3,730 feet to clear the 50-foot obstacle. If I had calculated the takeoff and 50 ft climb distances I could have determined a "go/no-go" point and speed. This "go/no-go" point should give a pilot time to throttle back and stop before running into the obstacles on the other end. Having a plan in advance would have allowed me to abort when the plane didn't accelerate as expected.

7. Didn't Operate the Airplane Properly (1). Cessna clearly indicates that the engine should be leaned to max RPM before take-off; my too-rich mixture sucked power from the engine.

8. Didn't Operate the Airplane Properly (2). Either the carb heat was not completely closed or the throttle slowly backed out a bit as we bounced down the long runway. I'm sure that tiny extra burst of power was the magic which got us off the runway. Whew.

9. Didn't Know the Local Area. The uphill climb for Runway 18 is barely noticeable on a normal day but painfully obvious as we struggled uphill. The

telephone wires at the end of the runway were another surprise. Check the local environment before the landing gear checks it for you.

10. Poor Decision-making. I should have aborted the take-off when things didn't feel right.

Another thought worth mentioning — the airplane performance specified in the POH are for a brand-new airplane with a crisp, tight, strong engine, no bugs on the wings or dents in the aluminum. How did my tired, student-abused, 20-year old C172 compare, with its ragged airframe and clapped-out old engine? Not good, not good at all.

Perhaps the most amazing aspect of this entire adventure is my favorite brother-in-law is still talking to me. That may end if he ever reads this tale; I may have to bribe my wife to not spill the beans. Nonetheless, the moral is a good one: compute the numbers, know the numbers, fly the numbers.

I survived my inexperience by the slimmest of lucky margins. Luck is not skill; hope is not a plan. I won't make the same mistake again… next time, I'll make a different mistake.

Sidebar

Know Your Numbers — Compute Your Density Altitude

There are many ways to determine density altitude. The simplest one is to listen to the AWOS; most modern systems report the density altitude rounded up to the nearest hundred feet. Flight computers and ForeFlight provide an exact number. Some POH have look-up tables. But it's not hard to do the math quickly and precisely, even in your head. All you need is the *pressure altitude,* the *actual temperature*, the *expected standard temperature* and the number "120."

Step 1: Climb into your plane, set the altimeter to 29.92 and read the altitude. This is your *pressure altitude.* It can be very different from your actual airport altitude. Pressure altitude changes every day, as weather systems wander through.

Step 2: Determine your actual outside temperature in Celsius. Just look at a thermometer.

Step 3: Compute the expected standard temperature for your airport's altitude. You only need to do this once; unless your airport migrates south for the winter, the ISA expected temperature for that airport will not change. The standard temperature always is 15˚C and the *standard thermal lapse rate* always is 2˚C for every thousand feet above sea level.[2] If your airport is at 6,000 feet,

[2] We fly in the troposphere, the lowest segment of the atmosphere. The troposphere runs from the surface of the Earth to 36,000 feet. In the troposphere, the temperature decreases linearly while the pressure decreases exponentially. The standard temperature lapse rate actually is −6.5°C (-11.7°F) per kilometer of altitude. This approximates −2°C (-3.6˚F) per 1,000 ft. Who in the world uses kilometers to measure altitude? I think the weather people have a lot of explaining to do!

subtract (6*2 = 12) degrees from 15˚C to get the adjusted expected standard temperature of +3˚C.

Step 4: Subtract your actual outside temperature from your ISA expected temperature.

Step 5: Multiply the differences in temperatures times 120 feet. Why 120? Because each degree increase in temperature equals the thinner air 120 feet above.

Step 6: Add those extra feet to your pressure altitude. Voilá — you have your density altitude.

For example, let's assume you're at an airport in New Mexico. You really don't care what the altitude is; forget that number. You need your pressure altitude. Climb into the cockpit, set your altimeter to 29.92 and read the altitude. Let's say it reads 6,500 feet. That's your pressure altitude.

Your expected ISA standard temperature is easy to compute. 6,000 feet = 6 x 2˚C = 12˚C. The ISA expected temperature would be 15-12 = +3˚C. Again, this will never change for that airport.

You glance over at the thermometer which shows a Spring-like 18˚C. Your density altitude computation would be:

Actual temperature 18˚C – 3˚C = 15 degrees

15 degrees x 120 ft = 1,800 ft.

1,800 + 6,500 = a density altitude of 8,300 feet

The aircraft will perform as if it were just about at 8,300 feet… for most of us, that's not so good.

Sidebar

Tips for Flying in High Density Altitudes

I have adapted these safety tips originally provided by AOPA to my flying in high DA situations:

- Check the forecasted local temps. Compute (don't guestimate) your density altitude. If it's going to be hot, fly early in the morning when temperatures are lower.
- Don't overload. Keep the aircraft's weight below 90% of maximum gross weight.
- Don't fill the tanks to the top. Fly shorter legs and make extra fuel stops.
- Avoid steep turns when you're low and slow. Don't fly in gusty conditions when the DA is high; the additional aileron inputs needed to combat strong gusts could stall a wing.
- Make multiple flights, even if it means ferrying passengers to another airport and coming back for the others.
- Know your airport and the runway lengths. Demand the longer runways. Be extremely cautious of obstacles.
- Know your airplane. If you don't, fly around the pattern without passengers to learn your aircraft's performance. You should know if

your aircraft climbs more efficiently with flaps. You also should know if retracting the landing gear causes a temporary increase in drag.

- Absolute minimums: You definitely should know your V-speeds and the “feel” of normal acceleration. if you do not have 80% of your takeoff speed by the runway's halfway point, abort the take-off. That means having 48 knots IAS in a lightly-loaded Cessna 172.

About the Author

Dr. Mike Jones is a 4,000 hour commercial-rated pilot who takes both his Cessna Centurion and his light sport taildragger to grass runways whenever he can find them. You can reach him at PilotMike2012@gmail.com.