That old bugaboo density altitude is again in season and so is the unwary pilot

High, Hot, Heavy—Helpless

by DON DOWNIE / AOPA 188441

Denalt density altitude computers for fixed- or variable-pitch propellers are an improvement over the venerable Koch chart.

■■ It happens every summer. Aircraft accident statistics show a rash of density altitude mishaps as high-altitude airports, free of snow and mud, again get busy when warm weather and longer days bring vacationing fliers out of the woodwork.

Every pilot has heard about the problems of density altitude—that combination of high temperature, high altitude, humidity and—to a lesser extent—a long list of subtleties that can accumulate into a no-takeoff or a no-climb situation. Unfortunately, density altitude doesn't make very exciting reading, and it is usually presented in a textbook, pass-the-written-exam format that is likely to be passed over quickly.

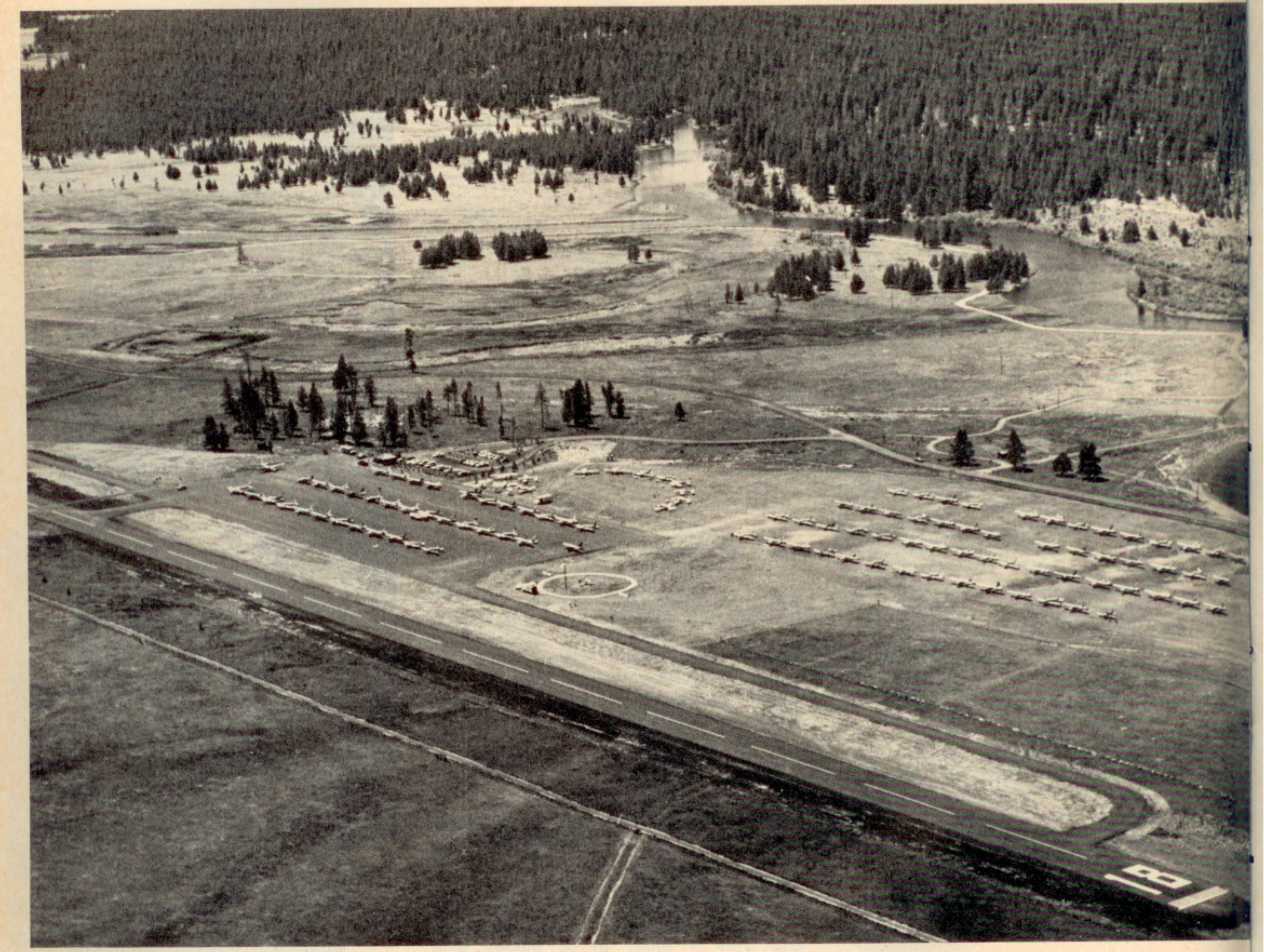
One effort to make the subject more interesting is the FAA's annual Density Altitude Roundup, scheduled for its fourth annual session at Bend (Ore.) Municipal Airport on July 23–25. At an elevation of 3,452 feet, this 3,700-foot runway can have a density altitude of over 7,000 feet with 100°F temperatures. The roundup program consists of lectures on aircraft performance at altitude, illustrated discussions of wilderness airports (with emphasis on takeoff performance and pilot techniques), medical effects at altitude, and search and rescue procedures.

The program, held for the past three years at nearby Sunriver Airport, has increased in attendance each year with more than 225 pilots and 150 aircraft attending in 1975. AOPA has held a Mountain Flying and a Pinch Hitter Course in conjunction with this program.

One of the flight-line exercises was to figure out at what point down the runway a pilot would pass over an imaginary 50-foot obstacle. A novel theodolite was used, and most of the competing pilots overestimated their capabilities.

Density-altitude calculations can be the most important aspect of preflight planning that a pilot can make, just as a timely 180-degree turn in approaching weather may be the most important in-flight decision. Careful attention to the performance charts of the particular airplane involved, its loading, the density altitude and takeoff surface involved, coupled with proper use of the DENALT computers (improved over the venerable Koch chart), should make the solution of any density altitude problem a routine textbook exercise. Unfortunately, it doesn't always work that way. There are just too many variables involved to come up with a set of numbers that will fit every airplane under every situation.

The Koch chart, which served many



Sunriver, Ore., Airport was host to the 1975 Density Altitude Roundup. Its 4,155-foot field elevation can turn into a density altitude of up to 8,000 feet with 100°F temperature.

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of us as a bible for years, has been supplemented by one of two DENALT computers (U.S. Government Printing Office, 50¢ each); one for aircraft with fixed-pitch propellers and one for controllable props. Almost every aircraft with a controllable prop will perform better at altitude than its fixed-pitch counterpart, despite its added weight.

Supercharged and turbocharged powerplants fall into a whole new ballpark that is not touched here. Twin-engine aircraft add many additional variables.

Consider the little things that can have an affect on your airplane at density altitude. Any one of the following items, and several others, can affect your takeoff roll and resulting rate of climb.

1. New engines are guaranteed within −2 to +5% of rated power. A −2% engine will perform below "numbers" expectations.

2. Long grass, sand, mud or deep snow will slow your takeoff roll.

3. Soft tires and/or dragging brakes hurt.

4. Runway gradient. For every 1% increase in runway upslope, a 2–4% increase in takeoff roll can be expected.

5. Frost, dirt, or even a coating of summer bugs on your lifting surfaces can be a factor.

6. The aging of the airframe. Minor hangar rash and dings on both lifting surfaces and—even more important—on the propeller will be a disadvantage.

7. Aging of the powerplant. After an engine reaches its best power following break-in time, there is no set amount of power loss as time builds up. As long as the engine is within tolerances, little or no power loss can be expected. However, it is safe to assume that reciprocating engines don't go up in horsepower after the high-friction, break-in period has passed.

8. Humidity. A U.S. Navy training manual states succinctly: "If water vapor enters the induction system of a reciprocating engine, the amount of air available for combustion is reduced, and since most carburetors do not distinguish water vapor from air, and enrichment of the fuel-air ratio occurs . . ."

A "worst-case" illustration could be rain in the high desert, with water droplets on the prop and wings and puddles on the runway where every splash takes energy and produces a 2- to 3% increase in drag. "That cloudburst feels good to you, the pilot, on a hot day," explains aerodynamicist Irv Culver (AOPA 117226), "but your airplane doesn't like it at all.

"Water vapor will make your engine sound nice because it has less tendency to detonate, but it also produces less power. Then try to abort a takeoff on a wet runway, and you could slide up to four times as far as on a dry pavement. Using a dirt runway, your muddy slide could go almost to infinity."

9. Proper leaning at altitude can be a book by itself, and the best book available is the engine-operations section of the aircraft manual for the airplane/engine combination you're flying. Basically, carbureted engines should be leaned to best rpm and enrichened "slightly." An EGT gauge is a help with leaning to peak temperature and then enrichening 100°F.

Fuel-injected engines should be leaned according to the fuel-flow chart monitored with an EGT. A cylinder-head temperature gauge also helps to warn of a too-lean, too-hot condition. The whole idea is to get the best possible power out of your engine without damage; so if you must gamble, gamble slightly on the rich side.

10. FAA certification requirements for light aircraft call for a sea level, standard day rate of climb of 300-fpm minimum or 11.5 times the stalling speed in takeoff configuration converted to rate of climb in fpm. Thus, if your aircraft stalls at 70 mph, the minimum rate of climb at sea level would be 70 times 11.5 or 805 feet per minute. As the speed goes up, the angle of climb decreases, making obstacles at the far end of the field become of more interest at an alarming rate.

11. Weight and balance. Again, go by the book, and if in doubt, off-load everything you really don't need. Make two trips with one passenger at a time to a larger, lower field. Don't add any more fuel than is absolutely required (with adequate reserves, of course) to reach a lower airport. The FAA requires that all takeoff and climb performances for certification be accomplished in a forward CG condition where the greatest downloads are imposed on the tailplane, causing the poorest climb performance. However these numbers are not necessarily reflected in the operations manual where the manufacturer may choose to show the numbers for the same weight carried in an aft CG condition.

12. Perfect pilot technique is an impossibility. Trained factory pilots, approach this perfection while low-time pilots, particularly those not too familiar with a particular make or model, may attempt to rotate too early and never get off the ground because the drag increase from a high angle of attack is more than the limited available horsepower will handle. While indicated airspeed at liftoff remains the same for all altitudes, the airplane will be traveling along the runway faster to attain this airspeed at higher density altitude runways. Thus, the unwary pilot may let his feeling of a high enough ground speed trick him into believing he has enough airspeed for liftoff, and consequently he may try to pull the airplane off the runway before it is ready.

13. Unfamiliar airports and unexpected, although predictable, downdrafts. A takeoff into a 20-knot wind may be fine for getting into the air quickly, but if the runway is pointed toward a high ridge, the pilot can expect downdrafts that might put him right back on the ground.

14. Mechanical items like dirty air filters, or restricted air-hose ducting may be acceptable at sea level, yet become critical at higher elevations.

15. Ground effect. Here again, hard and fast "numbers" are unavailable since every aircraft type is somewhat different. Essentially, ground effect occurs up to an altitude equivalent to one-half wingspan above the ground. Ground effect is an important factor in calculating helicopter performance at altitude, but it is usually treated in passing for general aviation studies.

Obviously, comes the question: Since a low-wing aircraft has its wing three to four feet closer to the runway than a high-winger, will it take off more readily in critical conditions? We asked this question to engineers like John Thorp (AOPA 022461), Irv Culver, and Joe Tymczyszyn. ("Tym" is in FAA flight test for the Western Region and was one of the founders of the Society of Experimental Test Pilots.) All agreed that a low-wing aircraft with the same aspect ratio (span vs. chord) wing would get off the runway in ground effect slightly better than a high winger. However, none of these experts would hazard a guess as to the amount of extra performance. Many low-wing aircraft have stubby wings and a lower aspect ratio, while a high percentage of the high-wingers have longer, thinner wings so the advantage can cancel out.

Old-timers will remember propeller-driven transports that skimmed the water with two engines out on the same side and were able to remain in the air only in ground effect. One such case involved a C-97 that lost one propeller en route to Hawaii. The prop damaged the second engine on that side and some of the aircraft's structure. Yet the plane stayed in the air, skimming just above the water, in ground effect all the way to Hawaii where a straight-in approach was made safely.

A climb out of ground effect is similar to some loss in climb efficiency. Veteran, former FAA GADO Chief Jim Dewey, of Santa Paula, Calif., reports that the classic comment following a density altitude mishap that occurred after coming out of ground effect is: "I was doing okay and then my engine lost power."

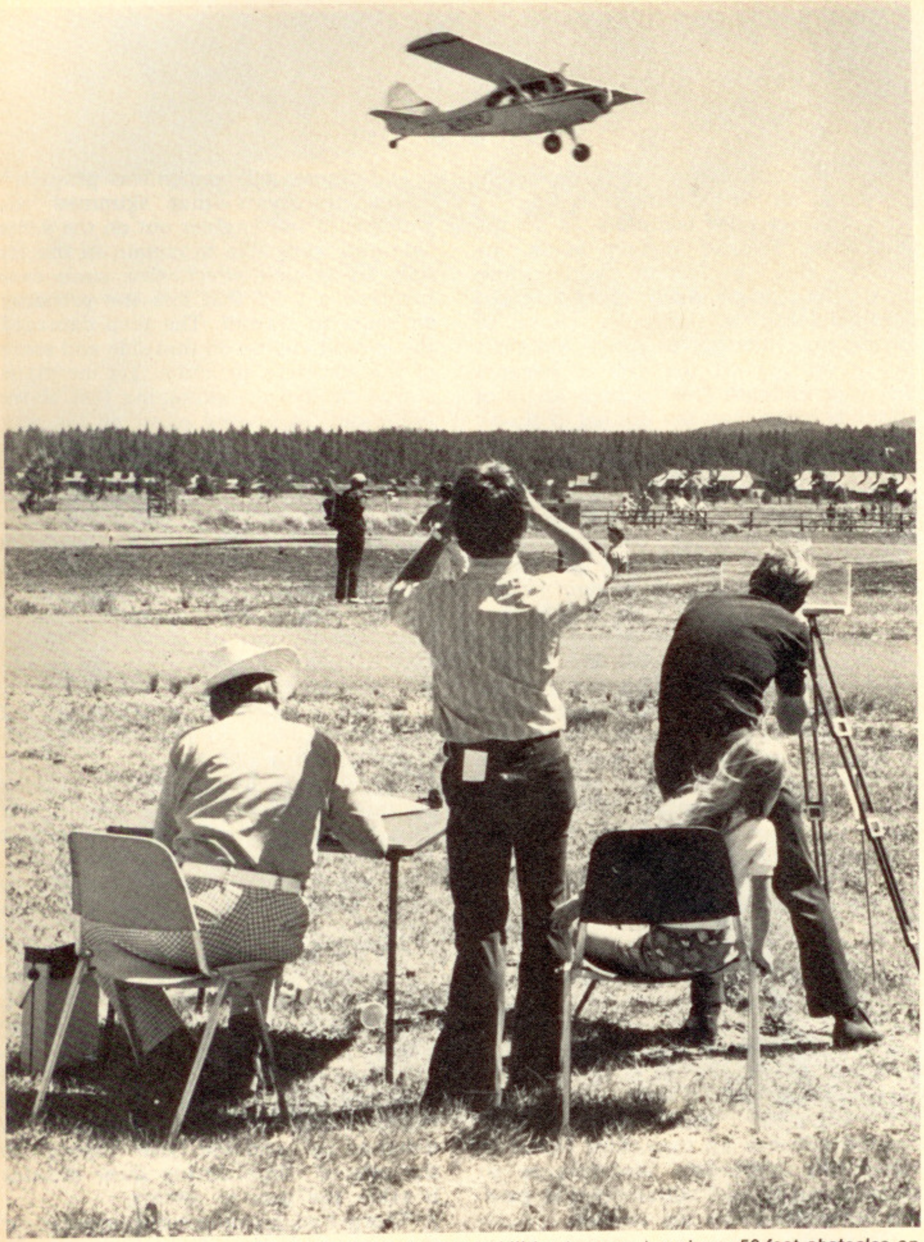
After reading the preceding list of takeoff variables, veteran designer John Thorp had two additions.

16. If you're flying a retractable-gear aircraft, drag may be 20–30% higher with the gear extended vs. the aircraft in a clean, best-climb configuration. This added drag may increase to as much as 50% while the gear is "in transit" with gear-well doors opening and closing, according to Thorp.

Any pilot with a retractable can easily check this out for himself at a safe altitude by setting the plane up in a takeoff configuration—gear down, flaps as required, takeoff power and recommended indicated takeoff speed. Then note the rate of climb. Next, cycle the gear from down to up, and see what happens to the rate of climb during those seconds it takes the gear to retract.

Thorp had an interesting request for the manufacturers of single-engine aircraft, particularly the lower-powered models that are the primary objects of this discussion. He would like to see the aircraft handbooks list the sea-level distance from start to takeoff roll to the liftoff point and then stop as is required in the certification of twins. At the present time, maximum-performance landing-roll distance figures are not required for light, single-engine aircraft. Thorp would like to see the distance from takeoff speed to full stop on a dry runway at a 5,000-foot elevation also listed in the manual. This distance would be virtually a straight-line plot, according to Thorp, and would give the pilot a tool with which to estimate his go/no-go point down any given runway.

Then, all the preceding variables—and perhaps some of the pilot's own—could be cranked into the go/no-go



Thedolite "scores" pilots' abilities to cross imaginary 50-foot obstacles on high-density altitude takeoffs. Most fell short of their expectations.

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distance, giving the pilot some reasonable ground reference point at which to abort his takeoff without getting so far down the field that there's nothing to do but keep on going in hopes of getting off the ground before running off the end of the runway.

We visited the Grand Canyon last summer. The 9,000-foot jet runway is 6,605 feet above sea level, but when we called in for a landing, the FAA tower advised, "The density altitude is now 9,200 feet."

Later, with taxi instructions, we were advised, "The density altitude is now 8,900 feet." While no nationwide program advising pilots of density altitude has yet been instituted by the FAA, individual tower chiefs have taken it upon themselves to add this vital information. It is our opinion that this data should go on both ATIS and tower calls any time the density altitude reaches 5,000 feet.

William S. "Mike" Hunter, acting chief of the Grand Canyon Tower, reports, "In the summer of 1974, the tower started a density altitude awareness program after a Cherokee crashed on takeoff. The Cherokee was overloaded and the temperature, high. A density altitude table was computed for the airport, and the current density altitude was issued to each departing aircraft. Two more serious accidents occurred during the remainder of the season, resulting in the deaths of two persons and the serious injury to four more.

"After 1974, we decided that more needed to be done to alert pilots to the dangers of flying from an airport high in altitude. Density altitudes reach as high as 10,000 feet during summer months. In May 1975, we published a fact sheet cautioning pilots of the dangers of high-density altitude with some do's and don'ts and other information concerning the airport. We appointed an accident prevention counselor for the area—Jerry Terstiege, of Grand Canyon Airlines—who talked to pilots, giving them tips on flying at high-density altitude airports in hot weather. The tower continued to issue the density altitude to each departing pilot."

At the end of the 1975 season (the Grand Canyon Tower is open from March 1 to October 15), the accident count was zero. Similar, but less extensive, programs are planned for Flagstaff, Springerville, Holbrook, Show Low and St. John, Ariz., this summer.

Most airports prone to extremely high-density altitude conditions are located in mountainous terrain and frequently present a downwind, downhill, avoid-a-downdraft decision. At the popular South Lake Tahoe Airport, elevation 6,262 feet, the 8,500-foot hard-surface Runway 18-36 has mountains rising to 7,768 feet, four and one-half miles south of the field. At one time the FAA tower would advise takeoffs away from the hills and over the lake even with tailwinds up to 15 knots. This procedure has been discontinued in the past three years, but departing pilots can still takeoff downwind to avoid the hills if they request such a departure. Of eight major accidents since 1970, five occurred off the south end of the field.

As a personal preference in lower-powered economy aircraft, I will request a takeoff downwind, away from the hills, so that all I have to clear may be a growth of pine trees, followed by miles and miles of lake for an uninterrupted climb. Again, considering lower-powered aircraft, if the wind at South Lake Tahoe is too strong to make a downwind takeoff well within the performance capability of the airplane, I'll leave it tied down until later in the day—or until another day. □