Altitude and Altimeters – Part 2

Before we dig into more new stuff let's do a quick review of what we learned in Part 2.

International Standard Atmosphere (ISA) is when at sea level the Atmospheric Pressure (AP) is 29.92 inches of mercury ("hg) and the temperature is 15 degrees centigrade. The ISA standard lapse rates are 1"Hg pressure and 2 degrees centigrade temperature per 1,000 feet of altitude change. Less pressure and cooler temperature going up, higher pressure and warmer temperature coming down. The atmosphere is almost never at ISA standard. Warm temperatures lower the pressure, cool temperatures increase the pressure.

Altimeters show change in elevation in accordance with the ISA lapse rate. A one (1) "Hg change in atmospheric pressure results in a 1,000 foot change in altitude. As the AP decreases, the altimeter shows an increase in altitude. As the pressure increases, the altimeter shows a decrease in altitude. Anything that causes a change in atmospheric conditions (air mass movement, temperature change), results in a change in pressure.

Indicated Altitude is what is showing on the face of the altimeter. Indicated Altitude is sometimes also your height above sea level, but only under certain conditions.

Pressure Altitude is you height above the atmospheric level where the pressure is 29.92 "Hg. Pressure Altitude is used for all altitude assignments above 18,000 MSL, as well as, in aircraft performance calculations involving Density Altitude and True Airspeed.

<u>Density Altitude</u>

Density altitude is the altitude your airplane "feels" like it's at and is used for performance calculations. Aircraft performance data in the pilot operating handbook assumes your airplane is operating at sea level on an ISA standard day, which almost never occurs. To know how your plane is going to perform in "real life" you need to know the Density Altitude.

Density Altitude is mostly used to make "go, no-go" takeoff decisions, especially at high altitude airports on a hot day. Density Altitude can have a profound effect on both normally aspirated (non-turbo charged) engines and aircraft aerodynamic performance.

High Density Altitudes reduces engine power, makes takeoff and landing rolls longer, and reduces the airplanes ability to climb. In some cases a high Density Altitude may affect the amount of baggage, passengers and fuel load you can carry.

Density Altitude is Pressure Altitude corrected for non-standard temperature. You can determine Density Altitude by looking at a chart (usually found in the Pilot Operating Handbook "POH"), use a formula, or by using a type E-6B flight computer, either the manual or electronic one. In all probability you'll get a slightly different answer depending on which method you use. I believe, the private pilot written test uses the chart method.

However, for now we're going to cover calculating Density Altitude using the formula. Refer to other documentation for the chart method and how to use the computers. In all cases to determine the

Density Altitude you first need the current Pressure Altitude. From Part 2 we learned the formula for Pressure Altitude is:

PA = [(29.92 – current altimeter setting) X 1000 + field elevation].

According to the AOPA the formula for calculating Density Altitude is:
DA = PA+ [120 X (OAT – ISA temperature)] (OAT is outside air temperature)

ISA temperature is the tricky part.

The ISA standard temperature is 15 degrees centigrade at sea level and it decreases 2 degrees centigrade for each 1,000 feet of elevation above sea level. The formula for determining the ISA standard temperature for your airfield is:

ISA temp = 15 - (field elevation / 1,000 X 2)

We now have all the parts to the formula, here's an example:

723	feet - field elevation
13.6	ISA temperature at field elevation- degrees centigrade
29.78	current altimeter setting
14	outside air temp, OAT - degrees centigrade

PA = (29.92 – 29.78) X 1000 + 723
PA = 863 feet

DA = 863 + [120 X (14 – 13.6)]
DA = 911 feet (somewhat above field elevation)

Under certain conditions the Density Altitude can be lower than field elevation. In the above example change the outside air temperature to 11 degrees centigrade and work the formula again. The calculated Density Altitude is 551 feet, somewhat below field elevation.

You MUST be aware of what a high Density Altitude can do to the performance of your airplane. At high altitude Colorado airports in the summer time I've seen Density Altitudes several thousand feet above field elevation. In these conditions a 172 with four people, full fuel and lots of baggage might not even get off the ground.

True Altitude

True Altitude is your actual height above the average level of the sea – Mean Sea Level (MSL). When you've set the altimeter to the current altimeter setting it shows you Indicated Altitude, not True Altitude. True Altitude is Indicated Altitude corrected for non-standard atmospheric conditions.

Airport field elevations and height of obstacles are shown as True Altitude. I've not been able to find a formula that calculates True Altitude, however type E-6B flight computers have a procedure for determining True Altitude.

The difference between Indicated Altitude and True Altitude can be significant and possibly deadly. The rule of thumb of "High-to-Low, look out below" applies to what happens when you've set the most current pressure setting in the Kollsman window, but you're flying into an area where the atmospheric pressure is significantly lower than the ISA standard. Even thou your altimeter is set correctly the Indicated Altitude will be indicating an altitude that is much higher than your actual True Altitude, so "look out below". The same thing happens when flying into an area where the temperature is significantly lower (colder) than ISA standard, the same rule applies, "high-to-low, look out below". Low temperatures push the pressure levels down and if you're flying at 3,000 feet Indicated Altitude your True Altitude may actually be descending as you following the 3,000 foot pressure level down, all the while your altimeter is indicating 3,000 feet.

This is a good time to remind you that your altimeter <u>ONLY KNOWS ABOUT PRESSURE</u> and if you're flying at a constant Indicated Altitude what you're actually doing is following a particular pressure level, which under some conditions may actually be descending.

If you're flying in a mountainous area all of this can be a problem. If you have good visibility you'll see the mountains and adjust as needed, but in bad visibility situations be very careful. Plan your flight so that you'll be AT LEAST 1,000 feet above the highest terrain and always keep your altimeter set to the closest reporting station.