DOCUMENT
GSM-G-CPL.022

DOCUMENT TITLE
GENERAL OPERATIONS, FLIGHT PLANNING AND PERFORMANCE

CHAPTER 10 – DENSITY ALTITUDE

Version 1.1
October 2013

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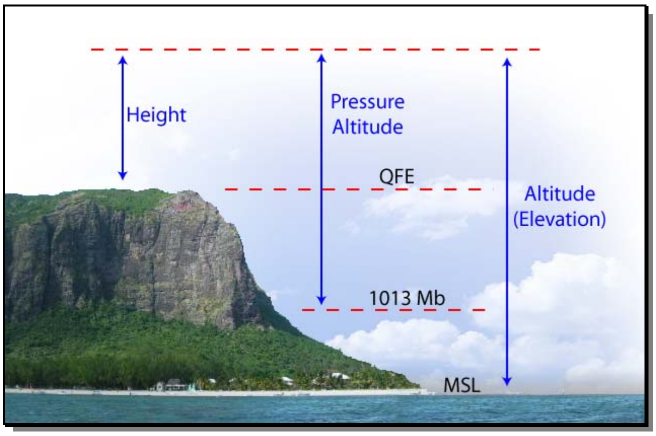
DENSITY ALTITUDE

INTRODUCTION

The more appropriate term for correlating aerodynamic performance in the non-standard atmosphere is density altitude, i.e. the altitude in the standard atmosphere corresponding to a particular value of air density.



Pressure Altitude corrected for temperature = Density Altitude

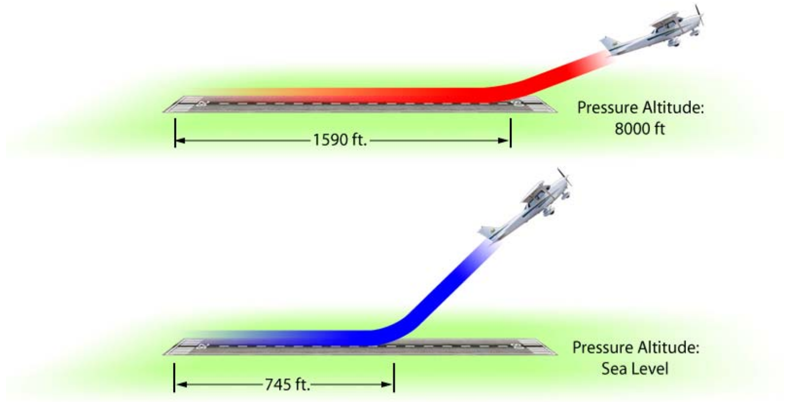
Density altitude is pressure altitude corrected for non-standard temperature. As the density of the air increases (lower density altitude), aircraft performance increases and conversely as air density decreases (higher density altitude), aircraft performance decreases.

A decrease in air density means a high density altitude;
and
An increase in air density means a lower density altitude.

Density altitude is used in calculating aircraft performance. Under standard atmospheric condition, air at each level in the atmosphere has a specific density, and under standard conditions, pressure altitude and density altitude identify the same level. Density altitude, then, is the vertical distance above sea level in the standard atmosphere at which a given density is to be found.

The computation of density altitude must involve consideration of pressure (pressure altitude) and temperature. Since aircraft performance data at any level is based upon air density under standard day conditions, such performance data apply to air density levels that may not be identical with altimeter indications. Under conditions higher or lower than standard, these levels cannot be determined directly from the altimeter.

Density altitude is determined by first finding pressure altitude, and then correcting this altitude for non-standard temperature variations. Since density varies directly with pressure, and inversely with temperature, a given pressure altitude may exist for a wide range of temperature by allowing the density to vary. However, a known density occurs for any one temperature and pressure altitude. The density of the air, of course, has a pronounced effect on aircraft and engine performance. Regardless of the actual altitude at which the aircraft is operating, it will perform as though it were operating at an altitude equal to the existing density altitude.

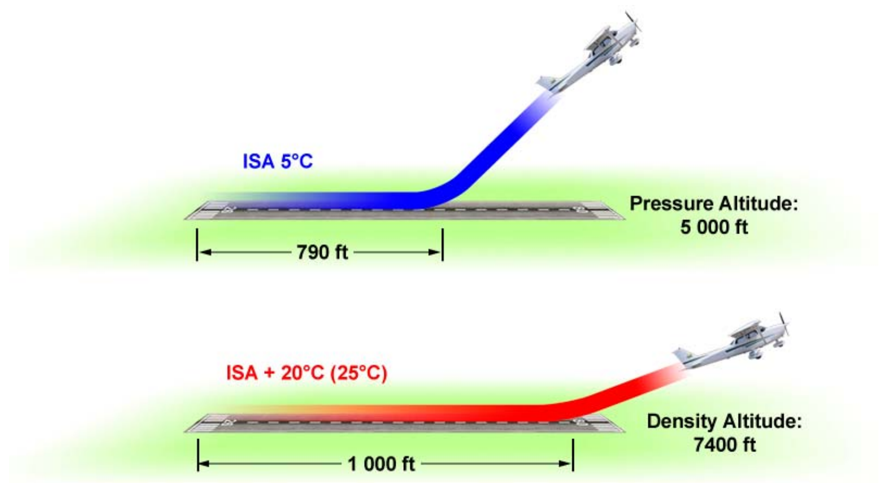


TAKEOFF DISTANCE

PRESS ALT FT	0°C GRND ROLL FT	0°C TOTAL FT TO CLEAR 50 FT OBS	PRESS ALT FT	0°C GRND ROLL FT	0°C TOTAL FT TO CLEAR 50 FT OBS
S.L.	745	1320	5000	1185	2125
1000	815	1445	6000	1305	2360
2000	895	1585	7000	1440	2635
3000	980	1740	8000	1590	2960
4000	1075	1920			

Air density is affected by changes in altitude, temperature and humidity. High density altitude refers to thin air while low density altitude refers to dense air. The conditions that result in a high density altitude are high elevations, low atmospheric pressures, high temperatures, high humidity, or some combination of these factors. Lower elevations, high atmospheric pressure, low temperatures, and low humidity are more indicative of low density altitude.

For **example**, when set at 1013.25 hPa, the altimeter may indicate a pressure altitude of 5 000 ft. According to the AFM/POH, the ground run on take-off may require a distance of 790 ft under standard temperature conditions. However, if the temperature is 20°C above standard, the expansion of air raises the density level. Using temperature correction data from tables or graphs, or by deriving the density altitude with a computer, it may be found that the density level is above 7 000 ft, and the ground run may be closer to 1 000 ft.



CALCULATING THE DENSITY HEIGHT

Density Height is an expression of air density in terms of its equivalent height in ISA.

Note:
Warmer air: Reduced density: Higher Density Height.
Colder air: Increased density: Lower Density Height.

The Density Height is found by using a formula based on the assumption that each degree Celsius of deviation from ISA temperature is approximately equivalent to 120 feet of air density change due to altitude:

DH = PH + (ISA Deviation x 120)

Calculating a Density Height:

Put the values of PH and ISA Deviation into the formula.

Example 1

Cruise Pressure Height: 5000 ft

OAT is: ISA + 10

Density Height = Pressure Height + (ISA Deviation x 120)

= 5,000 ft + (+10 x 120)

= 5,000 ft + +1,200

= 5,000 ft +1,200

= 6,200 ft

Example 2

Cruise at: FL 150

OAT: ISA - 10

Density Height = PH + (ISA Dev x 120)

= 15,000 ft + (-10 x 120)

= 15,000 ft + - 1,200

= 13,800 ft

Example 3

Cruise Altitude:	7,500 ft
Area QNH:	1000 hPa
OAT:	+1°C

Find the PH :

1013 hPa - 1000 hPa = 13 hPa x 30 ft

= 390 ft

7,500ft+390ft = 7,890ft

Find the ISA temp. at PH 7,890 ft :

7,890/1000 = 8 x 2

= 16° temp. drop.

+15°C - 16°C

= ISA temp - 1°C

Find the ISA Deviation:

- ISA is -1°C;
- OAT is +1°C;
- It is 2°C warmer than ISA conditions.
- The temperature is ISA + 2

Find the Density Height:

= PH + (ISA Dev. x 120)

= 7,890 ft+ (+2 X 120)

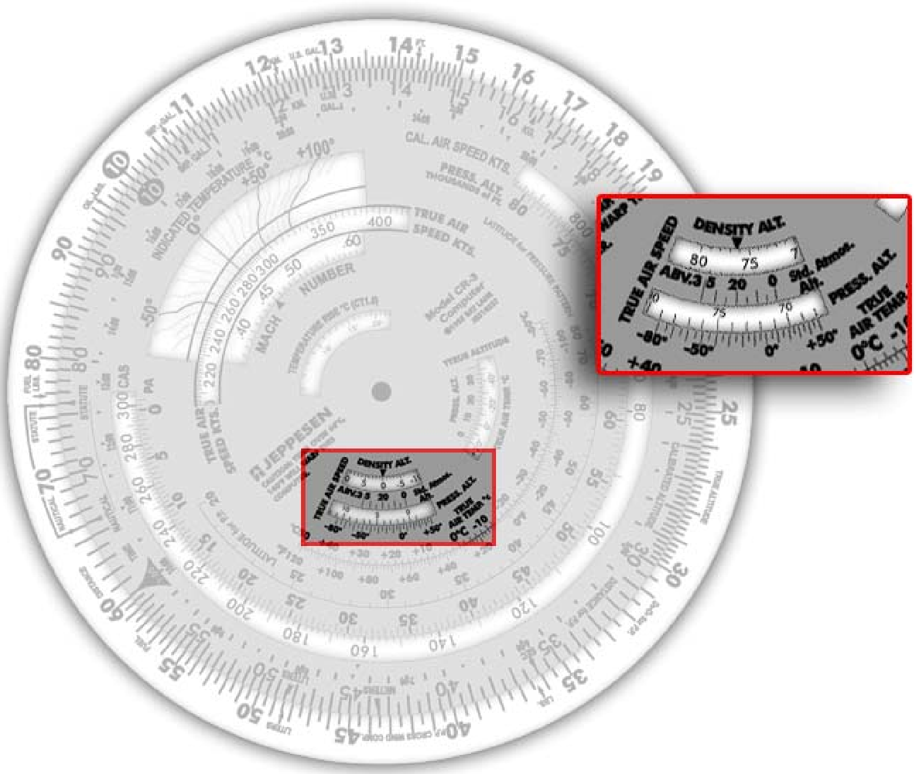
= 7,890 + (+ 240)

= 7,890 + 240

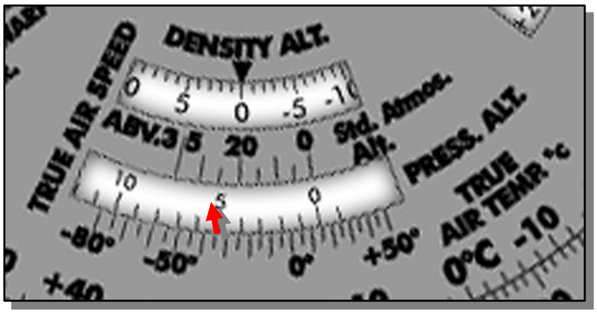
= 8,130 ft

DENSITY ALTITUDE AND THE FLIGHT COMPUTER

Using a flight computer, density altitude can be computed by inputting the pressure altitude and outside air temperature at elevation, altitude or flight level.



By using the window marked **PRESS. ALT.** and rotating until 0 Pressure Alt is displayed over an air temperature of +15°c, this is representing ISA conditions 1013 at +15°c and in ISA conditions Pressure altitude equals Density Altitude which is shown in the upper window marked **DENSITY ALT.** with a small arrow pointing to the density altitude, in this case **0**ft.



It is very important to understand that the PRESS ALT window is in 1000ft increments (5 shown in the PRESS. ALT window represents 5000ft) and there is a **+** and **–** temperature either side 0°c.

Now let's look at Question 1 from <u>calculating density height</u>

Cruise Pressure Height: 5000 ft

OAT is: ISA + 10

Density Height = Pressure Height + (ISA Deviation x 120)

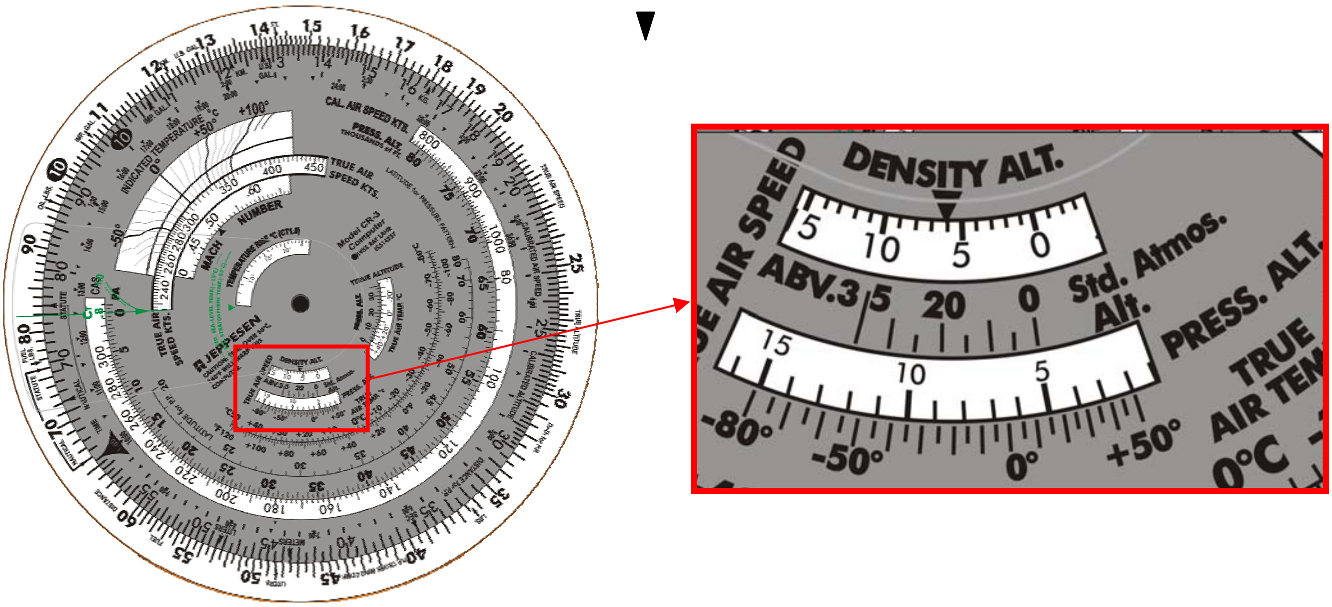
= 5,000 ft + (+10 x 120)

= 5,000 ft + +1,200

= 5,000 ft +1,200

= 6,200 ft

If we set our Pressure Height in the Press Alt window over the outside air temperature of +15°c (ISA +10).



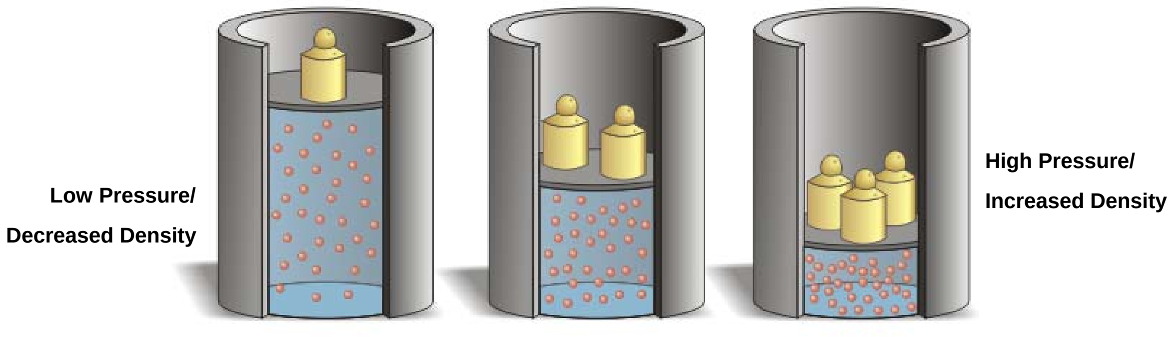
Then read directly from below the ARROW in the Density Alt window to find the answer

FACTORS AFFECTING AIR DENSITY

Effects of Pressure on Density

Since air is a gas, it can be compressed or expanded. When air is compressed, a greater amount of air can occupy a given volume. Conversely, when pressure on a given volume of air is decreased, the air expands and occupies a greater space. That is, the original column of air at a lower pressure contains a smaller mass of air. In other words, the density is decreased. Density is directly proportional to pressure. If the pressure is doubled.

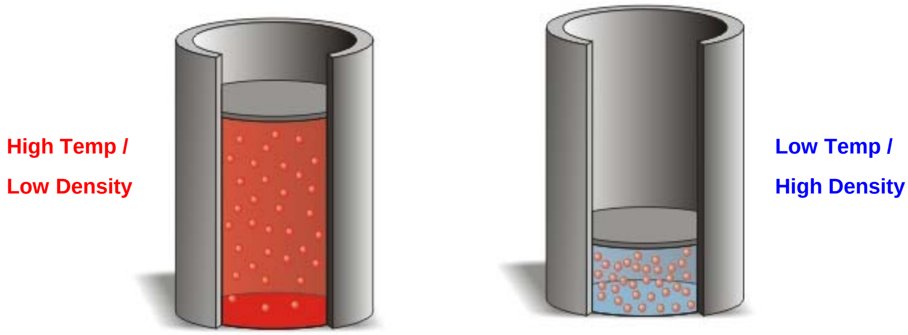
This statement is true only at a constant temperature.



EFFECT OF TEMPERATURE ON DENSITY

Increasing the temperature of a substance decreases its density. Conversely, decreasing the temperature increases the density. Thus, the density of air varies inversely with temperature.

This statement is true only at a constant pressure.



In the atmosphere, both temperature and pressure decrease with altitude, and have conflicting effects upon density. However, the fairly rapid drop in pressure as altitude is increased usually has the dominating effect. Hence, pilots can expect the density to decrease with altitude.

EFFECT OF HUMIDITY (MOISTURE) ON DENSITY

The small amount of water vapour suspended in the atmosphere may be almost negligible under certain conditions, but in high humidity conditions aircraft performance may be affected.

Water vapour is lighter than air; consequently, moist air is lighter than dry air. Therefore, as the water content of the air increases, the air becomes less dense, increasing density altitude and decreasing performance. It is lightest or least dense when, in a given set of conditions, it contains the maximum amount of water vapour.

The higher the temperature; the greater amount of water vapour the air can hold. Both the high temperature and the increase in humidity, causes the air to become less dense.

Humidity, also called “relative humidity,” refers to the amount of water vapour contained in the atmosphere, and is expressed as a percentage of the maximum amount of water vapour the air can hold. This amount varies with the temperature. Perfectly dry air that contains no water vapour, has a relative humidity of 0 %, while saturated air, that cannot hold any more water vapour, has a relative humidity of 100 %.

Humidity alone is usually not considered an important factor in calculating density altitude and aircraft performance; however, it does contribute. There are no rules-of-thumb or charts used to compute the effects of humidity on density altitude, so take this into consideration by expecting a decrease in overall performance in high humidity conditions.