Aircraft Performance: Atmospheric Pressure

FAA Handbook of Aeronautical Knowledge

Chap 10

Atmosphere

- Envelope surrounds earth
- Air has mass, weight, indefinite shape
- Atmosphere
  - 78% Nitrogen
  - 21% Oxygen
  - 1% other gases (argon, helium, etc)
- Most oxygen < 35,000 ft

Atmospheric Pressure

- Factors in:
  - Weather
  - Aerodynamic Lift
  - Flight Instrument
    - Altimeter
    - Vertical Speed Indicator
    - Airspeed Indicator
    - Manifold Pressure Guage

Pressure

- Air has mass
  - Affected by gravity
- Air has weight → Force
- Under Standard Atmospheric conditions
  - at Sea Level weight of atmosphere = 14.7 psi
- As air become less dense:
  - Reduces engine power (engine takes in less air)
  - Reduces thrust (propeller is less efficient in thin air)
  - Reduces Lift (thin air exerts less force on the airfoils)

International Standard Atmosphere (ISA)

- Standard atmosphere at Sea level:
  - Temperature 59 degrees F (15 degrees C)
  - Pressure 29.92 in Hg (1013.2 mb)

- Standard Temp Lapse Rate
  - -3.5 degrees F (or 2 degrees C) per 1000 ft altitude gain
    - Upto 36,000 ft (then constant)
- Standard Pressure Lapse Rate
  - -1 in Hg per 1000 ft altitude gain

Non-standard Conditions

- Correction factors must be applied
- Note: aircraft performance is compared and evaluated with respect to standard conditions
- Note: instruments calibrated for standard conditions

Pressure Altitude

- Height above Standard Datum Plane (SDP)

- If the Barometric Reference Setting on the Altimeter is set to 29.92 in Hg, then the altitude is defined by the ISA standard pressure readings (see Figure 10-2, pg 10-3)

Altitude (ft)	Pressure ("Hg)	Temperature	
		(°C)	(°F)
0	29.92	15.0	59.0
1,000	28.86	13.0	55.4
2,000	27.82	11.0	51.9
3,000	26.82	9.1	48.3
4,000	25.84	7.1	44.7
5,000	24.89	5.1	41.2
6,000	23.98	3.1	37.6
7,000	23.09	1.1	34.0
8,000	22.22	−0.9	30.5
9,000	21.38	−2.8	26.9
10,000	20.57	−4.8	23.3
11,000	19.79	−6.8	19.8
12,000	19.02	−8.8	16.2
13,000	18.29	−10.8	12.6
14,000	17.57	−12.7	9.1
15,000	16.88	−14.7	5.5
16,000	16.21	−16.7	1.9
17,000	15.56	−18.7	−1.6
18,000	14.94	−20.7	−5.2
19,000	14.33	−22.6	−8.8
20,000	13.74	−24.6	−12.3

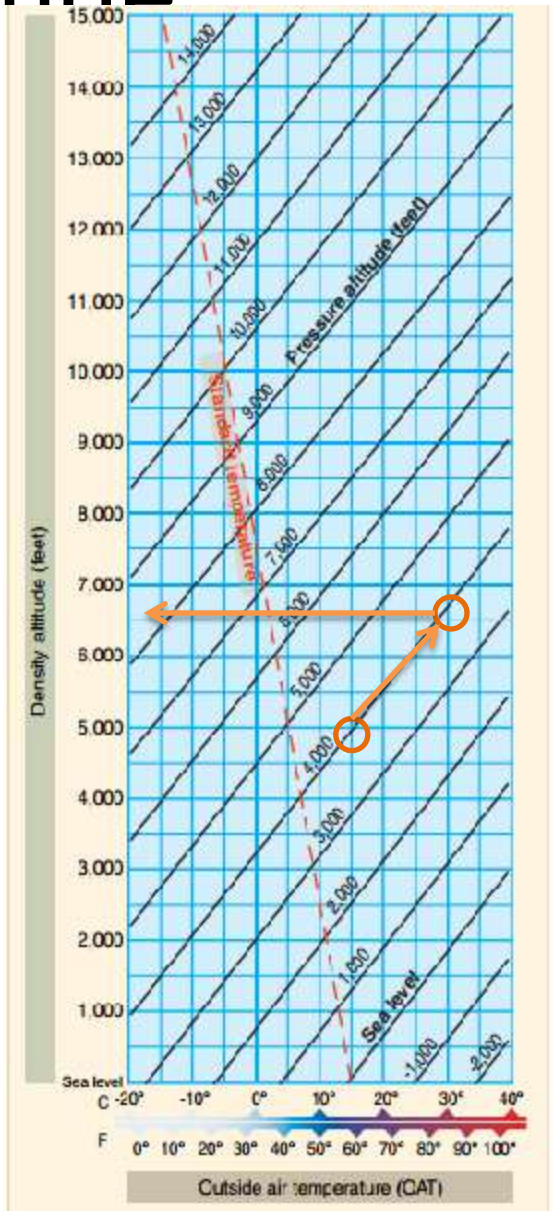
Density Altitude

- Used for correlating aerodynamic performance
- Density altitude = pressure altitude corrected for non-standard temperature
- Density Altitude is vertical distance above sea-level (in standard conditions) at which a given density is to be found
- Aircraft performance increases as Density of air increases (lower density altitude)
- Aircraft performance decreases as Density of air decreases (higher density altitude)

Density Altitude

1. Find pressure altitude
2. Correct altitude for non-standard conditions (i.e. Outside Air Temperature)
3. Read of Density Altitude

- Note: a given pressure altitude may exist for a range of temperature by allowing density to vary
- Note: A known density occurs for only one temperature and pressure



Density Altitude - Example

- Altimeter set to 29.92 in Hg, shows altitude of 5000’ when temperature is at standard temp
- Altimeters set to 29.92 in Hg, shows altitude of 7000’ when temperature is +20 degrees C above standard

High Density Altitude (worse performance)

- High elevations
- Low atmospheric pressures
- High temperatures

Low Density Altitude (better performance)

- Lower elevations
- High atmospheric pressure
- Low humidity

Ideal Gas Law

- D = Mass/Volume
- Density of a Gas = Molar Mass • Pressure / Universal Gas Constant • Temp
  - Density is proportional to pressure
  - Density is inversely proportional to temperature
- PV = nrT
  - Pressure
  - Volume
  - Temperature
  - n, r = constants

Effects of Pressure on Density

- Density is proportional to Pressure
  - At constant temperature
    - 2 X pressure = 2 X density
    - ½ X pressure = ½ X density

Effect of Temp on Density

- Density varies inversely with Temperature
  - Increasing temp decreases density
  - Decreasing temp increases density

Effect of Humidity on Density

- Water vapor is lighter than air
  - Moist air lighter than dry air
- Humidity increases → Air density decreases
  - Reduces performance

- Humidity defined as % of maximum amount of water the air can hold
  - Varies with temperature
    - Warm air holds more water vapor
    - Cold air holds less water vapor