

III.D. Performance and Limitations

References: FAA-H-8083-3; FAA-H-8083-23; FAA-H-8083-25; AC 61-84; POH/AFM

Objectives	The student should develop knowledge of the elements related to airplane performance and limitations as required in the necessary PTS.
Key Elements	<ol style="list-style-type: none">1. Density2. Density Altitude3. Airplane Performance
Elements	<ol style="list-style-type: none">1. Determining Weight and Balance2. Atmospheric Conditions and Performance3. Performance Charts4. Determining the Required Performance is Attainable5. Exceeding Airplane Limitations
Schedule	<ol style="list-style-type: none">1. Discuss Objectives2. Review material3. Development4. Conclusion
Equipment	<ol style="list-style-type: none">1. White board and markers2. References
IP's Actions	<ol style="list-style-type: none">1. Discuss lesson objectives2. Present Lecture3. Ask and Answer Questions4. Assign homework
SP's Actions	<ol style="list-style-type: none">1. Participate in discussion2. Take notes3. Ask and respond to questions
Completion Standards	The student has the ability to calculate the airplane's performance based on the current or expected conditions of a flight and decide whether or not the performance will suffice.

Instructors Notes:

Introduction:

Attention

Interesting fact or attention grabbing story

How exciting would it be to find out first hand, that the airplane actually doesn't have the ability to takeoff from a certain runway and that it also doesn't have the ability to clear the obstacle at the departure end?

Overview

Review Objectives and Elements/Key ideas

What

The Performance and Limitations section of the POH contains the operating data for the airplane; that is, the data pertaining to takeoff, climb, range, endurance, descent, and landing.

Why

The use of the operating data for the airplane is mandatory for safe and efficient operations

How:

1. Determining Weight and Balance

- A. $CG = \text{Total Moment} \div \text{Total Weight}$
 - i. Begin with the empty weight and make a list of everything that will be loaded in the airplane
 - a. People, items, fuel, etc. (note the weights of everything as well)
 - b. Be sure the weight of what you want to load is within the maximum weight limits
 - If the total weight is too high, remove items/people to get within weight limits
 - ii. Calculate the Moments of each item
 - a. To find the moments, use the graph or multiply the weight by the arm with the information in the POH
 - The weight/moment of the airplane are found in the weight and balance documents
 - iii. Then calculate the CG – (Total Moment/Total Weight)
 - a. For the DA20, compare the Total Weight and Total Moment on the graph in supplement 4
 - iv. Use the chart in Supplement 4 to determine whether the airplane is within limits

2. Atmospheric Conditions and Performance

- A. Atmospheric Pressure
 - i. Though air is light, it has mass and is affected by gravity and therefore, it has a force
 - ii. Under standard conditions at sea level, the average pressure exerted is approx 14.7 lbs/in
 - iii. Since air is a gas, it can be compressed or expanded
 - iv. Density of the air has significant effects on the airplane's performance
 - a. As the density of the air increases (lower air density), airplane performance increases and vice versa
- B. What Changes Air Density (DA)?
 - i. Barometric Pressure, Temperature, Altitude, and Humidity all affect air density
 - a. Density varies directly with pressure - As pressure increases, density increases and vice versa
 - b. Density varies inversely with temperature – As temp increases, density decreases and vice versa
 - c. Density varies inversely with altitude - As altitude increases, density decreases and vice versa
 - d. Density varies inversely with humidity – As humidity increases, density decreases and vice versa

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- In simple terms, the reason for this is that Oxygen molecules (O_2) are being replaced with water molecules (H_2O). Hydrogen is considerably lighter than oxygen. By replacing oxygen with hydrogen, the density of the air decreases
- C. How it affects Performance
- i. As the air becomes less dense, it reduces:
 - a. Power since the engine takes in less air
 - Power is produced in proportion to air density (As density increases, power does too)
 - b. Thrust since the propeller is less effective in thin air
 - Thrust is produced in proportion to the mass of air being accelerated, less dense air means less air being accelerated
 - c. Lift because the thin air exerts less force on the airfoils
 - As air density decreases, the lift efficiency of the wing is decreased
- D. Leaning the Engine
- i. At power settings less than 75% or at DA's > 5,000' the engine must be leaned for max power on takeoff
 - a. The excessively rich mixture deters engine performance
 - ii. At higher elevations, high temperatures may have such an effect on DA that safe operations may not be possible
 - a. Even at lower temperatures with excessive humidity, performance can be marginal and weight may need to be reduced

3. Performance Charts

- A. Airplane performance is found in Section 5 of the POH (Performance and Limitations)
- i. Supplement 4, for the DA20 (any charts not shown in the supplement are found in Chapter 5)
- B. Using the performance charts, and the accompanying instructions, we can calculate
- i. Cruise Performance
 - ii. Stall Speeds based on airplane configuration
 - iii. Wind Components (Crosswind and Headwind)
 - iv. Takeoff Distance and Landing Distance
 - v. Climb Performance (In cruise and takeoff configurations as well as Balked Landing)
 - vi. True Airspeed
 - vii. Maximum Flight Duration (Chart in which the Pressure Altitude is combined with RPM to find % bhp, KTAS, GPH)
- C. In order to make use of these charts we need to know the Pressure Altitude (PA)
- i. Pressure Altitude – The altitude indicated when the altimeter setting window is set to 29.92
 - a. $PA = 1,000(29.92 - \text{Current Altimeter Setting}) + \text{Elevation}$
 - EX: Altimeter = 30.42 and Elevation = 808, so PA = 308'
 - EX: Altimeter = 29.84 and Elevation = 808, so PA = 888'
 - ii. From Pressure Altitude we can compute Density Altitude
 - a. DA: PA corrected for non standard temperature (Directly related to airplane performance)
 - b. $DA = 120(\text{Current Temperature} - 15^\circ\text{C}) + PA$
 - EX: Temp = 23°C and PA = 308', so DA = 1,268'
 - EX: Temp = 03°C and PA = 308', so DA = -1,132
 - This is a very good estimate of DA, the equation is not perfect
- D. Once we have PA, we can start at the temperature at the bottom of the chart and move up to the PA
- i. From there, we move straight across until we reach the next stage of the chart
 - a. Once we reach the next step, follow the trend line and then move straight across
- E. This is done until we reach the performance number

4. Determining the Required Performance is Attainable

- A. Use the performance charts and relate them to the airport information (runway lengths, etc)
 - i. The charts will provide performance for all phases of flight
 - ii. But, remember, the charts don't make allowance for pilot proficiency or mechanical deterioration
 - a. Does the airplane have problems that may limit performance?
- B. There is always the possibility of changing weather resulting in useless original calculations
 - i. Just because the plane will perform well now doesn't mean it will perform well later
 - ii. Plan ahead

5. Exceeding Airplane Limitations

- A. Operating Limitations are in Chapter 2 of the POH
 - i. The limits here establish the boundaries in which the airplane can be safely operated
 - ii. Adverse Affects
 - a. Attempting to takeoff or land without enough runway
 - Can result in a crash into an obstacle or over-running the runway also damaging the plane
 - b. Attempting to clear an obstacle that the airplane performance will not allow at a certain weight
 - This can result in crashing into the obstacle
 - c. Not having enough fuel to reach the airport of intended landing, cruising at a high power setting
 - Can result in an emergency landing
 - d. Using the wrong type of fuel
 - Can result in detonation, causing significant damage to the engine
 - e. Exceeding the structural or aerodynamic limits by being overweight or outside CG limits
 - Can result in airplane damage or structural failure
 - Airplane control may be hampered and stall speeds may be affected
 - f. Exceeding the maximum crosswind component (20 knots)
 - This will greatly increase the difficulty of the landing, possibly resulting in a crash
 - The airplane may not have the ability to stay aligned with the runway, resulting in a crash or departing the landing surface

Conclusion:

Brief review of the main points

It is very important that before every flight, the pilot ensures the airplane can produce the required performance depending on the airport and atmospheric conditions.

PTS Requirements:

To determine that the applicant exhibits instructional knowledge of the elements related to performance and limitations by describing:

1. Determination of weight and balance condition.
2. Use of performance charts, tables, and other data in determining performance in various phases of flight.
3. Effects of exceeding airplane limitations.
4. Effects of atmospheric conditions on performance.
5. Factors to be considered in determining that the required performance is within the airplane's capabilities.