Effects of Density Altitude

Climb Gradient Study

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VERSION HISTORY

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REFERENCES

1. King Air 350 Pilot's Operating Handbook and FAA Approved Airplane Flight Manual, P/N 434-590169-0003, Rev A2
2. Embraer SCAP module, SM-320-B v302
3. Bombardier Computerized Airplane Flight Manual, Rev 3.2.1, Challenger 350
4. Gulfstream G550 Airplane Flight Manual, Revision 43

DEFINITIONS AND ABBREVIATIONS

- AFM – Airplane Flight Manual
- APG – Aircraft Performance Group
- ATR – Automatic Thrust Reserve
- ECS – Environmental Control System
- FT – Feet
- LB – Pounds
- OPERA – Optimized Performance Analyzer
- SCAP – Standardized Computerized Aircraft Performance

1. INTRODUCTION

This report will show the degradation of second segment climb gradient performance for a variety of aircraft as density altitude is increased. The following aircraft are reviewed in this report:

- King Air 350
- Embraer Phenom 300
- Bombardier Challenger 350
- Gulfstream G-550

2. ANALYSIS SETUP

2.1 Elevations Temperature, and Density Altitude

An elevation of 5901 feet with standard altimeter and ISA temperature is selected for the initial calculation of each aircraft's climb gradient to show performance at Truckee Tahoe Airport (KTRK).

- ISA temperature for elevation of 5901 feet: 3.3 °C
- Temperature to approximate 9500 ft density altitude: 35.8 °C
- Actual Density Altitude at 5901 feet elevation and 35.8 °C: 9497.145

This report does not include calculation methods for determining ISA for an elevation nor density altitude for a given pressure altitude and temperature combination.

2.2 King Air 350 Configuration

The climb gradients provided for the King Air 350 are derived from the Net Take-off Flight Path – Second Segment chart as found on page 5-61 of the King Air 350 AFM (King Air 350 Pilot's Operating Handbook and FAA Approved Airplane Flight Manual, P/N 434-590169-0003, Rev A2). The associated configuration for all King Air 350 calculations is:

- Flaps: UP
- One Engine Inoperative
- Static Takeoff Power
- Brake Release Weight: 14500 LB
- Wind: 0 KTS
- Air Conditioning: On
- Bleed Air: On
- Engine Anti-Ice: Off

Performance at 9500 ft density altitude is limited, therefore structural takeoff weight was not used for this analysis.

2.3 Embraer Phenom 300 Configuration

The climb gradients provided for the Phenom 300 are derived from the Embraer SCAP program (Embraer SCAP module, SM-320-B v302). This SCAP program complies with the Embraer OPERA software for calculating performance. The associated configuration for all Phenom 300 calculations is:

- Flaps: 1
- One Engine Inoperative
- Static Takeoff Power
- Brake Release Weight: 17500 LB
- Wind: 0 KTS
- Enhanced ATR System: On
- Engine Anti-Ice 1/2: Off

- Engine + Wingstab Anti-Ice 1/2: Off

Performance at 9500 ft density altitude is limited, therefore structural takeoff weight was not used for this analysis.

2.4 Bombardier Challenger 350 Configuration

The climb gradients provided for the Challenger 350 are derived from the Fixed Level Off Flight Path module in the Challenger 350 CAFM (Bombardier Computerized Airplane Flight Manual, Rev 3.2.1, Challenger 350). The Challenger 350 CAFM does not provide the means to calculate a second segment net climb gradient directly. The analysis provided in this report divides the net height associated with a 400 ft gross level off height by the calculated distance to attain that net height. Multiplying this value by 100 results in an average second segment net climb gradient and is sufficient for this analysis. The associated configuration for all Challenger 350 calculations is:

- Flaps: 10°
- One Engine Inoperative
- Static Takeoff Power
- Brake Release Weight: 40600 LB
- Gross Level-Off Height: 400 FT
- Wind: 0 KTS
- Bleeds: On
- Engine Anti-Ice: Off
- Engine + Wing Anti-Ice: Off

2.5 Gulfstream G-550 Configuration

The climb gradients provided for the G-550 are derived from the Available Net Gradient Takeoff Second Segment Climb chart as found on pages 10 and 11 of the G-550 AFM (Gulfstream G550 Airplane Flight Manual, Revision 43). The associated configuration for all G-550 calculations is:

- Flaps: 10°
- One Engine Inoperative
- Static Takeoff Power
- Brake Release Weight: 86500 LB
- Gross Level-Off Height: 1500 FT
- Wind: 0 KTS
- Drag Index: 0
- ECS Bleeds: On
- COWL Anti-Ice: Off
- COWL + Wing Anti-Ice: Off

Performance at 9500 ft density altitude is limited, therefore structural takeoff weight was not used for this analysis.

3. ANALYSIS RESULTS

This section provides the available second segment net climb gradient at 5901 feet elevation and ISA temperature, 5901 feet elevation and 35.8 °C (9500 ft density altitude) and the climb gradient reduction between the two data points.

	5901' @ ISA	9500' Density	Reduction
King Air 350	3.84	1.41	-2.43
Embraer Phenom 300	6.74	1.79	-4.95
Challenger 350	5.26	1.93	-3.33
Gulfstream G-550	3.70	1.93	-1.77

This data shows the degradation of performance as density altitude increases.

4. CONCLUSION

This report covers the analysis methods utilized by APG to evaluate the effect of increasing density altitude for a variety of aircraft. The degradation of performance is presented for all aircraft types analyzed.