Chapter 5
Performance

Table of Contents

Flight Planning Example

General

This chapter of the manual contains performance information for the PA-28R Arrow, and provides the flight crew with the necessary performance data for normal operations. It also provides specific performance factors to be considered during abnormal and emergency operations.

Included are representative examples, demonstrating proper use of the charts and / or tables. The chapter is arranged in the order most typically used by the flight crew (i.e.: preflight, planning, flight, etc.).

Performance information associated with optional systems and equipment is provided in Section 9 (Supplements) of the Pilot's Operating Handbook / Airplane Flight Manual.

The performance information presented in this chapter is based on measured flight test data corrected for I.C.A.O. standard day conditions and expanded for the various parameters of weight, altitude, temperature, etc. The performance charts are not factored and do not make any allowance for varying degrees of pilot proficiency or mechanical deterioration of the aircraft.

Preflight Planning

Effects of conditions not considered on the charts must be evaluated by the flight crew, such as the effects of a soft or grass runway surface on takeoff and landing performance, or the effect of winds aloft on cruise and range performance. Endurance can be grossly affected by improper leaning procedures, and in flight fuel flow and quantity checks are recommended.

The information included in this chapter provides the procedures necessary to complete a Bridgewater State College Takeoff and Landing Data (TOLD) Card, Navigation Log, and Flight Plan Form. The performance charts include examples to show how relevant information is calculated.

Takeoff and Landing Data (TOLD) Card Completion Instructions

This section provides step-by-step instructions for completing the aircraft performance side of the Bridgewater State College Takeoff and Landing Data (TOLD) Card.

NOTE

Altering the date on a previously used TOLD card is unacceptable.
A new TOLD card shall be completed for each aircraft and each flight.

Pilot / Instructor / Date
Enter last name of the Pilot and Instructor, and date of the flight event. Ensure both pilot names (if appropriate) are on the card for non-instructional flights.

ATIS Code
Enter the current ATIS code, if available.

Active Runway
Enter the runway in use as obtained from any valid current report (ATIS, Common Traffic Advisory Frequency (CTAF), UNICOM, Flight Service Station (FSS)).

Winds
Enter current surface winds from any current valid report (ATIS, automated weather reports (ASOS or AWOS), UNICOM, FSS).

Ceiling / Visibility
Enter the ceiling and visibility from any current valid report (ATIS, automated weather reports (ASOS or AWOS), Pilot Report (PIREP), FSS).

Temperature
Enter the surface temperature from any current valid report (ATIS, automated weather reports (ASOS or AWOS), UNICOM, FSS).

Dewpoint
Enter the dewpoint from any current valid report (ATIS report, automated weather reports (ASOS or AWOS), FSS).

Altimeter Setting
Enter the altimeter setting (in inches Hg) from any current valid report (ATIS, automated weather reports (ASOS or AWOS), UNICOM, FSS). If a current local altimeter setting is not available, use departure airport elevation.

Density Altitude
With the values of pressure altitude and surface temperature, calculate and enter density altitude.

NOTE

The following formula may be used to determine density altitude.

$$PA+(120 \times \{CT - ST\}) = DA$$

PA – Pressure Altitude
CT – Current Surface Temperature (°C)
ST – Standard Temperature (°C)
DA – Density Altitude

Pressure Altitude
Calculate and enter takeoff pressure altitude.

NOTE

The following two-step formula may be used to determine pressure altitude.

$$(29.92 - CA) \times 1000 = X$$

$$X + FE = PA$$

CA – Current Altimeter Setting
FE – Field Elevation
PA – Pressure Altitude

Runway Length
Enter the lengths, at the departure and arrival airports, of runways of intended use. Obtain this information from the Airport / Facility Directory or other appropriate publication. Ensure that there is sufficient runway available at all airports for the planned flight.

Headwind, Crosswind, and Tailwind Components
It is essential to calculate and enter the headwind, crosswind, and tailwind components to ensure that college, flight crew, and aircraft limitations will not be exceeded. Use the appropriate performance graphs in the Flight Standards Manual.

Aircraft Performance Data

This section of the TOLD Card includes takeoff, runway, cruise, landing information, and V speeds.

Takeoff Distance Normal
Insert the takeoff distance calculated by utilizing the Takeoff Distance performance chart. Calculate for normal takeoffs using 0^0 flaps, and for short-field takeoffs using 25^0 flaps. An example of how to perform this calculation is depicted on the chart.

Takeoff Distance Over 50 Ft. Obstacle
Insert the takeoff distance calculated by utilizing the Takeoff Distance performance chart. Calculate for normal takeoffs using 0^0 flaps, and for short-field takeoffs using 25^0 flaps. An example of how to perform this calculation is depicted on the chart.

Cruise
Note the MP and RPM setting to be used for cruise segments of the flight, as appropriate.

RPM Select either a Best Power or Best Economy setting. The RPM setting for the flight can then be established using the appropriate performance chart.

MP Select the cruising altitude of the flight, then select either Best Power or Best Economy. The manifold pressure (MP) setting for the flight can then be established using the appropriate performance chart.

TAS Select the cruising altitude of the flight, then select either Best Power or Best Economy. The true airspeed (TAS) for the flight can then be established using the appropriate performance chart.

GPH Select either Best Power or Best Economy setting. The expected gallons per hour (GPH) fuel burn for the flight can then be established using the appropriate performance chart.

PX Area Transition
Enter the transition cruise airspeed to be used for transiting to and from the practice area.

Runway Condition (Contamination)
Enter the current (departure) runway information. For arrival, enter the expected runway condition. More information on runway contamination is provided later in this chapter.

Landing Distance Normal
Insert the landing distance calculated by utilizing the Landing Distance Ground Roll performance graph. Calculate for normal and short-field technique. An example of how to perform this calculation is depicted on the graph.

Landing Distance Over 50 Ft. Obstacle
Insert the landing distance calculated by utilizing the Landing Distance Over 50 Ft. Barrier performance graph. Calculate for normal and short-field technique. An example of how to perform this calculation is depicted on the graph.

V Speeds

V_{S0} Stalling speed or the minimum steady flight speed in the landing configuration.

V_{S1} Stalling speed or the minimum steady flight speed in a specified configuration.

V_R Rotation speed (varies with the weight of the aircraft).

V_X Best angle of climb airspeed (i.e. the airspeed that delivers the greatest gain in altitude in the shortest possible horizontal distance).

V_Y Best rate of climb airspeed (i.e. the airspeed that delivers the greatest gain in altitude in the shortest possible time).

V_{LO} Landing Gear Operating Speed: Maximum airspeed for either retracting or extending the landing gear.

V_{LE} Landing Gear Extended Speed: Maximum airspeed at which the airplane can be flown with the landing gear extended.

V_{FE} Maximum flap extended speed (i.e. the highest airspeed permissible with the wing flaps in a prescribed extended position).

V_A Maneuvering speed (i.e. the maximum speed at which application of full available aerodynamic control will not overstress the aircraft). V_A decreases at lighter weights.

V_{NO} Maximum structural cruising speed. Do not exceed this speed except in smooth air, and then only with caution.

V_{NE} Never exceed speed. Do not exceed this speed at any time.

Approach Speed
Speed that must be used for the approach and landing portion of the flight. For instrument approaches both the approach speed and the landing speed must be listed.

Takeoff and Landing Data (TOLD) Card

Aircraft N #__________	**Departure Information**	**Arrival Information**
Winds		
Visibility		
Ceilings (AGL)		
Temperature/Dew Point		
Local Altimeter		
Active Runway(s)		
Density Altitude		
Pressure Altitude		
Runway Length Available		
Headwind Component		
Tailwind Component		
Crosswind Component		
Aircraft Performance Data		
Takeoff Distance (Normal)_____________ Short Field Technique:___________		
Power Setting (MP/RPM) Cruise:___/___ PX Area Trans:___/___ FF:______		
Runway Condition DRY Contamination: RAIN SNOW ICE		
Landing Distance (Normal):__________ Short Field Technique:___________		
V_{s1} __________ V_y __________ V_{NE} ____________________________		
V_{so} __________ V_{FE} __________ $V_{LO:}$ Up______ Down_____ V_{LE}_______		
V_g __________ V_A __________ Approach Speed ______________		
V_x __________ V_{NO} _________ Best Glide (Gear Up) _________		

Flight Planning Example

Aircraft Loading
Begin flight planning by calculating aircraft weight and center-of-gravity (see Chapter 6 Weight & Balance). The following example is excerpted from the PA-28R-200 Arrow Pilot's Information Manual (PIM), (Piper Aircraft, Inc., 1971)

Begin by calculating the aircraft weight and center of gravity by utilizing the information provided in Chapter 6 Weight & Balance.

The Basic Empty Weight (BEW) for the aircraft is determined by the manufacturer and entered in the aircraft Pilots Operating Handbook / FAA Approved Airplane Flight Manual. Verify that any alterations to the aircraft that affect the weight and balance have been properly noted in the FAA Approved Airplane Flight Manual, weight and balance record in the aircraft logbook, or the inspection summary in the Bridgewater State College aircraft "can".

NOTE

The inspection summary in the Bridgewater State College aircraft can is NOT the official aircraft weight and balance record. Official weight and balance data can be located in the FAA approved Airplane Flight Manual issued for the specific aircraft.

Determine the actual fuel weight before starting additional weight and balance calculations.

1.	Basic Empty Weight	1615.9 lbs
2.	Occupants (2x170 lbs)	340 lbs
3.	Baggage and Cargo	39.1 lbs
4.	Fuel (6 lbs x 50 gal)	300 lbs
5.	Takeoff Weight	2650 lbs
6.	Landing Weight	2504 lbs

The TW is below the maximum of 2650 lbs, and the weight and balance calculations have determined the C.G. position within the approved limits.

Takeoff and Landing
After determining the aircraft loading, takeoff and landing performance must be considered and carefully planned. Current and forecast conditions at the departure and destination airport must be acquired, evaluated and updated throughout the flight.

After determining the aircraft loading, all aspects of the takeoff and landing must be considered. All of the existing and forecast conditions at the departure and destination airport must be acquired, evaluated and maintained throughout the flight.

Apply the departure airport density altitude conditions and takeoff weight to the appropriate Takeoff Performance and Takeoff Ground Roll graphs in Chapter 5 of this manual. This will determine the takeoff ground roll and takeoff ground roll over a 50 Ft. barrier. Remember to use the correct graph line for the appropriate flap setting. Note that the performance charts depict values for an aircraft at maximum gross weight 2650 lbs, and on a paved level dry runway surface.

Perform the landing distance calculations in the same manner using the existing or forecasted conditions (as appropriate) at the destination airport once the landing weight has been established using the appropriate table(s). Note that the performance charts depict values for an aircraft at maximum gross weight 2650 lbs, and on a paved level dry runway surface. Note also that the Landing Distance chart depicts a landing performed with full flaps.

The conditions for the example flight are listed below.

	Departure Airport	**Destination Airport**
1. Pressure Altitude	1500 ft	1500 ft
2. Temperature	20°C	20°C
3. Wind component	4 KTS (Head)	4 KTS (Head)
4. Runway Length Available	3000 ft.	4600 ft.
5. Ground Run or Roll (approx.)	1400 ft.	800 ft.
6. Runway required (approx.)	2300 ft.	1400 ft.

Perform landing distance calculations in the same manner using current or forecast conditions at the destination airport. Calculate landing distances only <after> calculating expected landing weight.

NOTE

The remaining performance charts in this example assume zero winds. Winds aloft must be considered when computing climb, cruise and descent performance.

NOTE

The Airspeed Indicator for this aircraft is marked initially as MPH (outer ring) and converted to KIAS (inner ring). Flight crews must take care to adhere to published airspeed limitations regardless of the type of marking used.

Climb

Determine climb performance (time, distance, fuel burn) using density altitude and rate of climb values for the desired cruise pressure altitude and corresponding cruise outside air temperature, then apply the existing conditions at the departure field to the table. Subtract these values from those for the desired cruise pressure altitude and outside air temperature. Calculate approximately 14 gal/hr fuel flow at 110 MPH cruise climb. The results provide true time and distance components for the climb segment of the flight corrected for field altitude and temperature.

Next, apply the existing conditions at the departure field to the graph. Apply the desired cruise power setting from the performance table. Then subtract the values from the departure airport from those for the cruise pressure altitude. This will provide true fuel, time and distance components for the climb segment of the flight corrected for field altitude and temperature.

These example numbers are calculated using the above instructions and the appropriate graph.

1. Cruise Pressure Altitude	4000 ft
2. Cruise OAT	10°C
3. Fuel to Climb (3 gal minus 1.2 gal)	1.8 gal
4. Time to Climb	Approx. 5.5 min
5. Distance to Climb	Approx. 10 NM

Descent

Descent planning is often overlooked, but it must be calculated prior to determining cruise flight total distance. Use the cruise pressure altitude and the OAT to determine basic fuel, time, and distance for descent. Adjust by subtracting the field pressure altitude at the destination airport to give the actual fuel, time, and distance for the descent to field elevation.

The following figures are used for the flight planning example.

1. Descent Altitude	4,000 ft
2. Fuel to Descend (Idle Power)	0.5 gal
3. Time to Descend	4 min
4. Distance to Descend	10 NM

Cruise

Use total flight distance, and subtract the previously calculated figures for distance to climb and distance to descend. The remaining figure is total cruise flight distance. Use the appropriate cruise power table for the desired setting.

Calculate cruise performance using true airspeed. Calculate TAS by selecting a cruise power setting and referring to the pressure altitude and temperature values.

Divide cruise distance by the cruise speed to determine cruise flight time. Calculate cruise fuel consumption by multiplying the cruise fuel flow by the cruise flight time.

The following figures are used for the flight planning example.

1.	Total Distance	200 NM
2.	Cruise Distance	180 NM
3.	Cruise Power (Economy)	65% power
4.	Cruise Speed	150 MPH (130 KTS) TAS
5.	Cruise Fuel Consumption	9.2 GPH
6.	Cruise Time	83 min.
7.	Cruise Fuel	12.7 gal

Total Flight Time
Calculate total flight time by adding for the sum of time to climb, the time to descend and cruise flight time. Convert time in minutes to time in hours for all calculations.

The following flight time is required for the flight planning example.

1.	Total Flight Time	1.4 hrs

Total Fuel Required
Total fuel required is determined by adding fuel to climb, fuel to descend cruise fuel. When the total fuel (in gallons) is determined, multiply this value by 6lbs/gal, which gives the total fuel weight used for the flight.

The following total fuel calculation is used for the flight planning example.

1.	Total fuel required	15.0 gal
2.	Total weight of required fuel	90.0 lbs

Flight Planning Considerations

Contaminated Runway Environment
A contaminated runway can occur in any climate, and it is important to understand the effect that this may have on aircraft performance. Information provided below is referenced from AC 91-79 Runway Overrun Prevention (11/6/2007).

<u>Standing Water</u>

Standing water is usually the result of heavy rainfall and/or insufficient drainage. A runway is considered to be contaminated by standing water when more than 25% of the runway surface area (whether in isolated areas or not), within the required length and width being used, is covered by 1/8 inch or more of standing water.

Slush

Slush is snow saturated with water that displaces with a splatter when pressed upon. It is normally encountered at temperatures around 5°C (41°F). A runway is considered to be contaminated with slush when more than 25% of the runway surface area (whether in isolated areas or not), within the required length and width being used, is covered by 1/8 inch or more of slush.

Wet Snow

Wet snow will easily stick together and tend to form a snowball if compacted by hand. A runway is considered to be contaminated with wet snow when more than 25% of the runway surface area (whether in isolated areas or not), within the required length and width being used, is covered by 1/4 inch or more of wet snow.

Dry Snow

Dry light snow is loose and can easily be blown. If compacted by hand, it will readily fall apart. A runway is considered to be contaminated with dry snow when more than 25% of the runway surface area (whether in isolated areas or not), within the required length and width being used, is covered by the equivalent of more than 1/8 inch of dry snow.

CAUTION

Performance charts do not factor effects of contaminated runways or precipitation drag. Flight crews must carefully evaluate any expected impact on aircraft performance.

ASSOCIATED CONDITIONS AFFECTING PERFORMANCE

The charts, tables, and diagrams contained in this section are reprinted by permission from Piper Aircraft, Inc. They may not be reproduced without written permission from Bridgewater State College and Piper Aircraft, Inc.

WARNING

The information contained in the following performance chart(s) is presented for illustration purposes only and is not intended to predict the performance of any specific aircraft (Piper Aircraft, Inc.).

Power Off Stall Speed Vs. Angle of Bank

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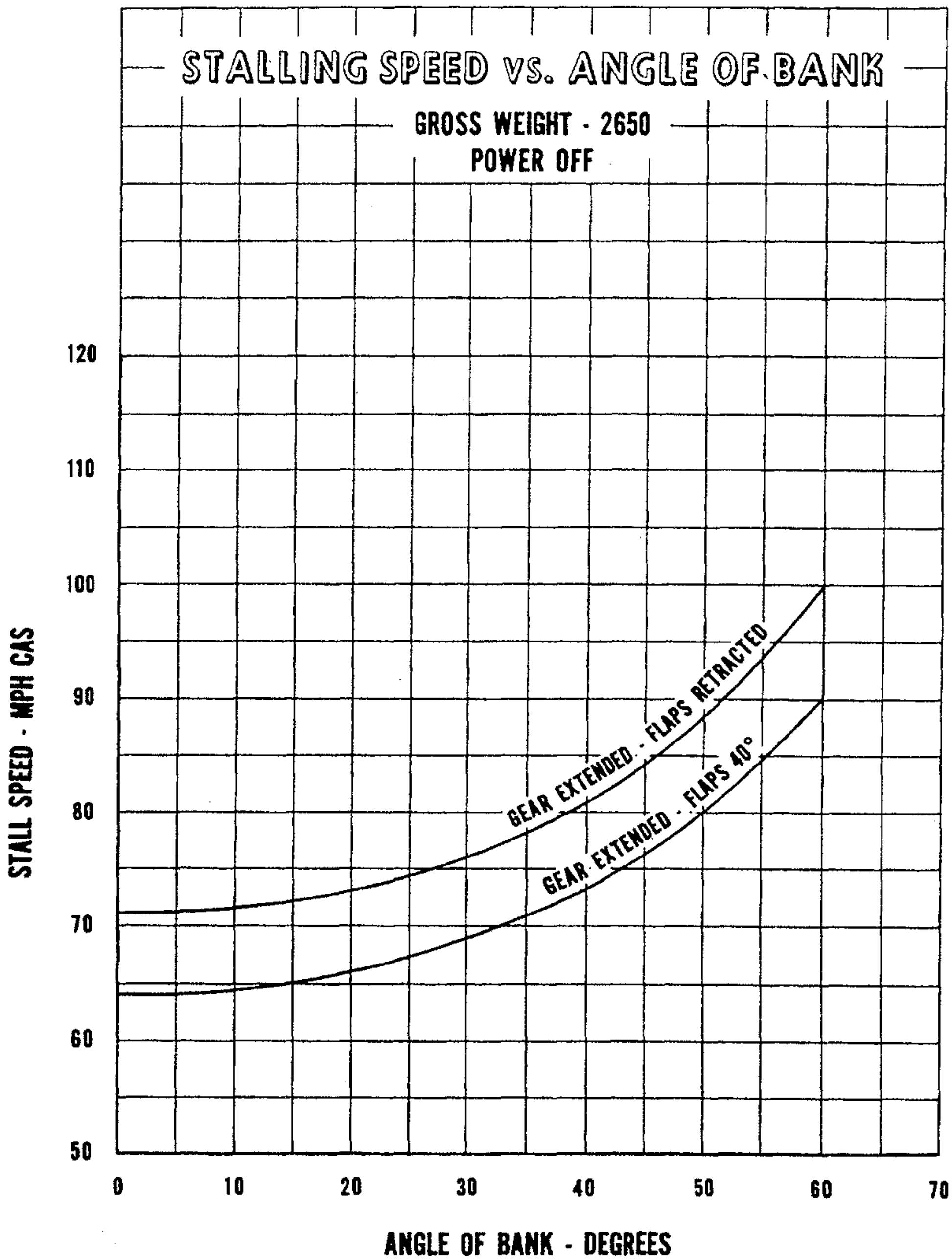

Altitude Conversion Chart

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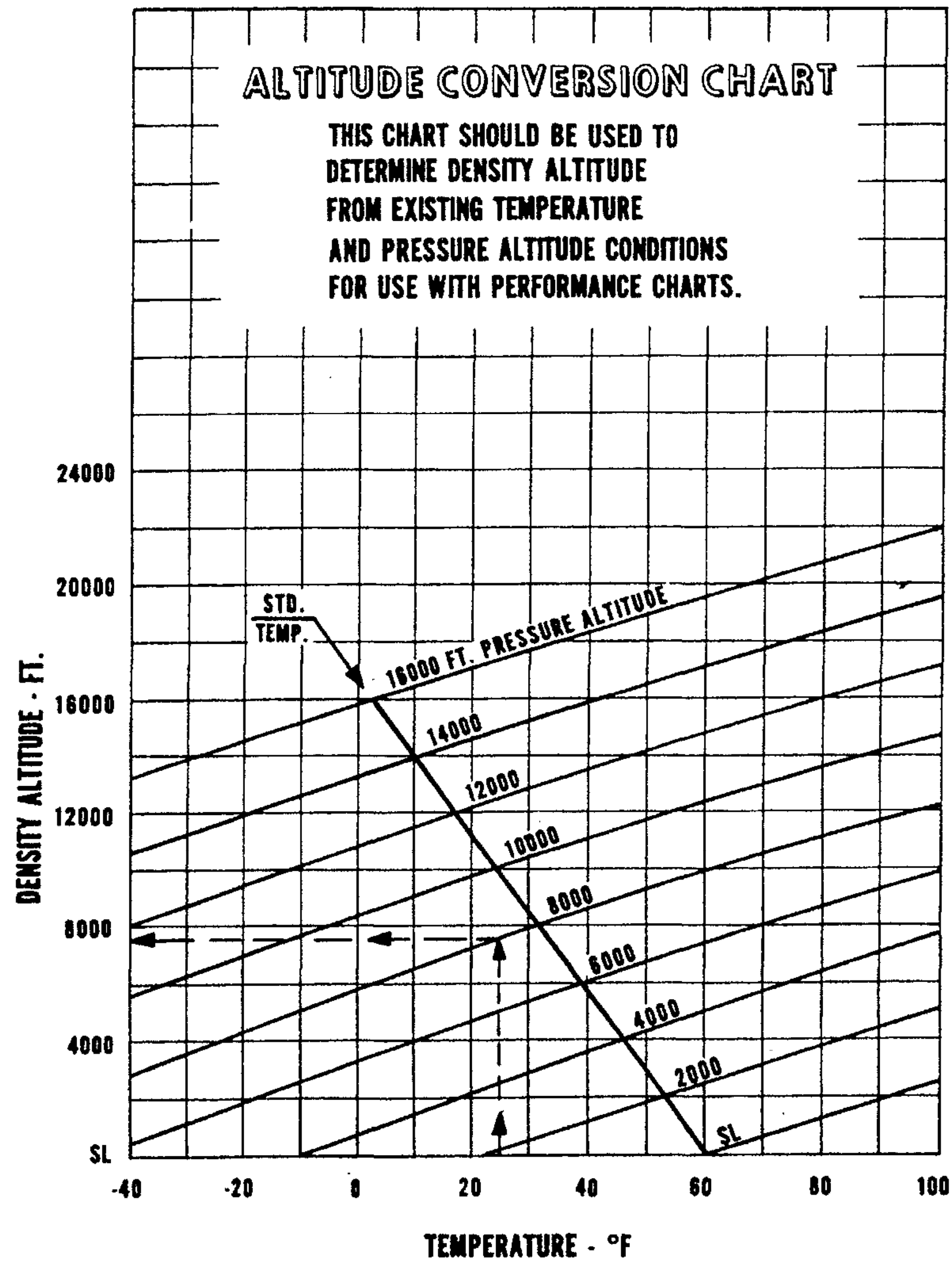

Takeoff Distance Vs. Density Altitude

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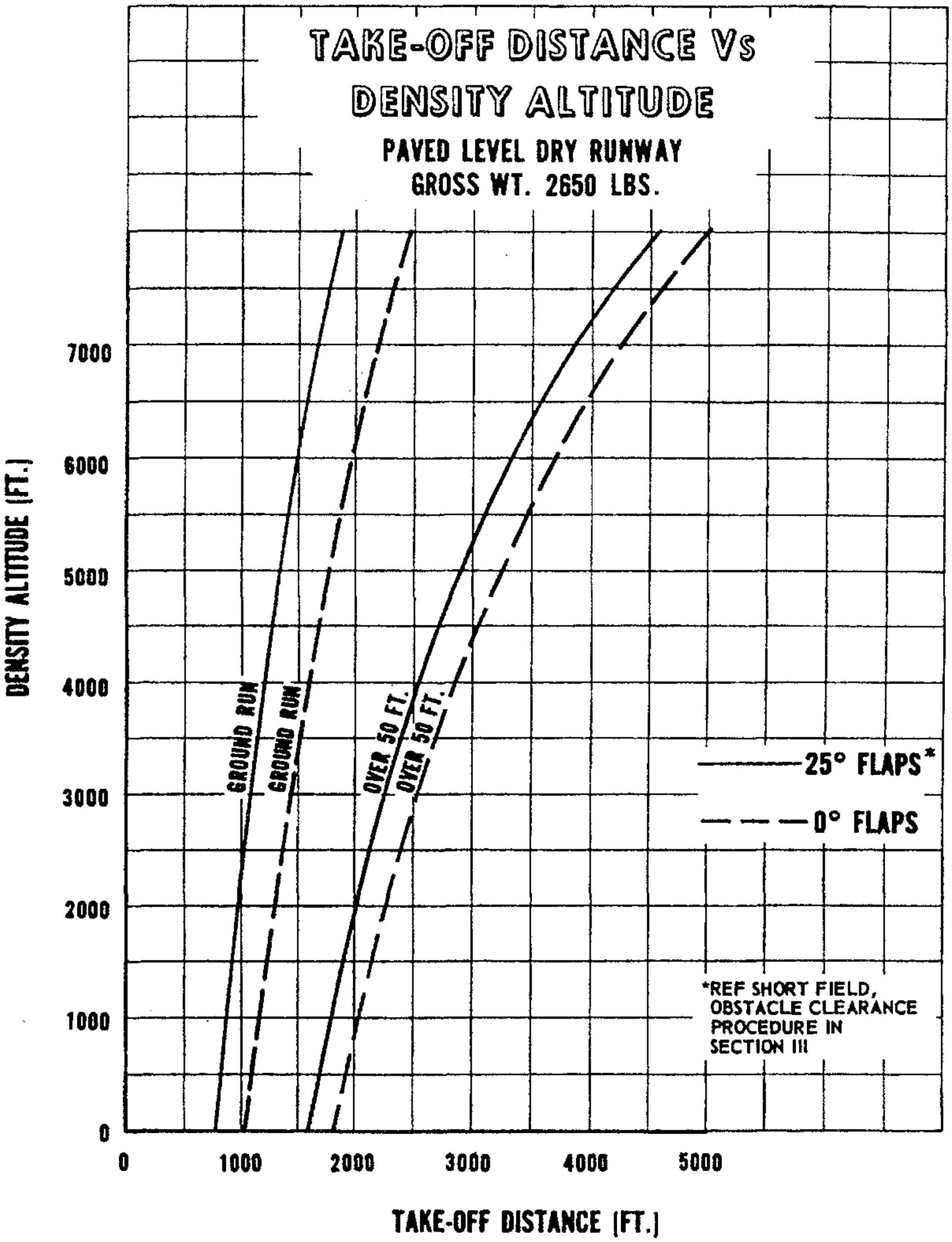

Rate of Climb Vs. Density Altitude

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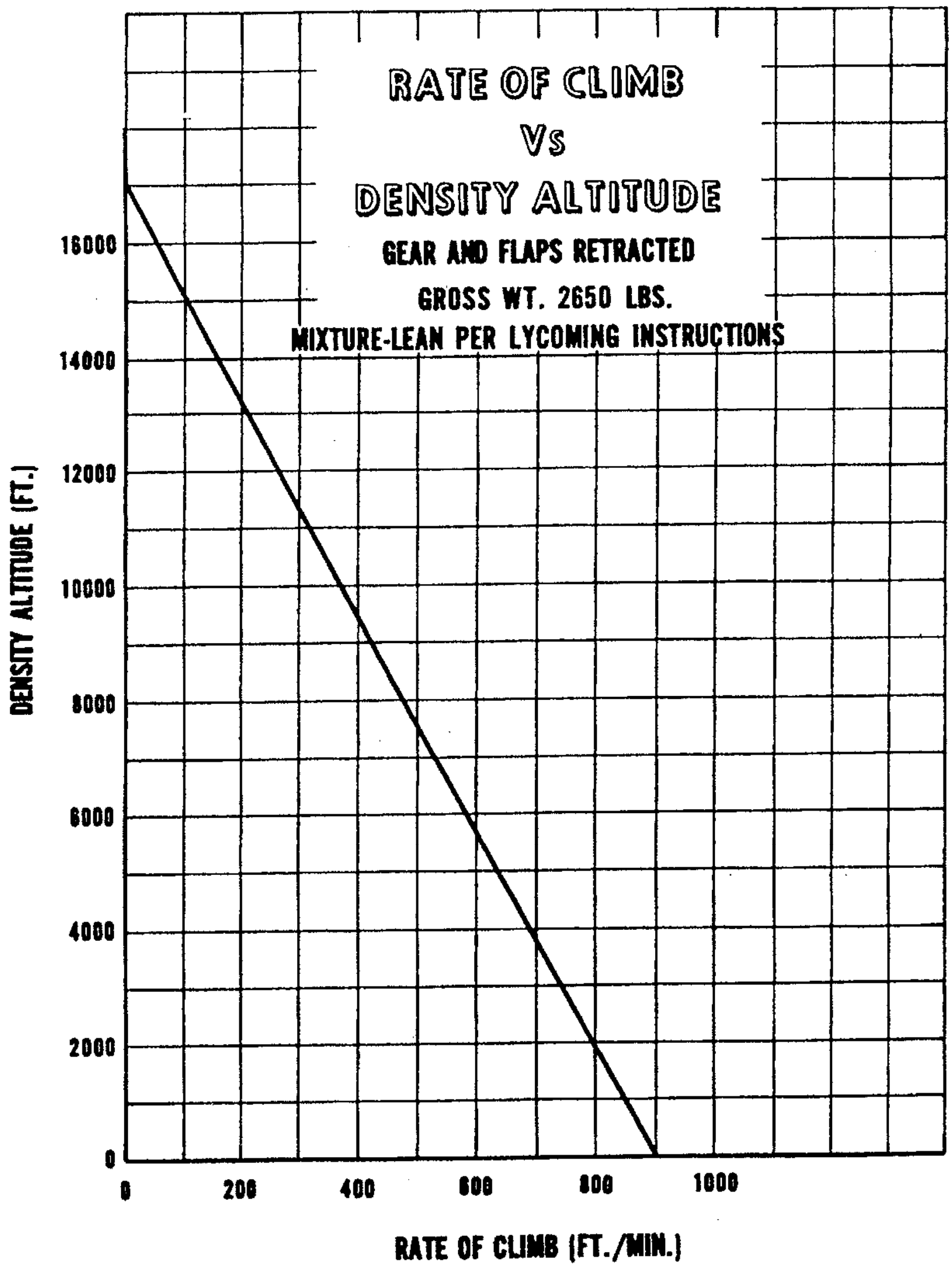

True Airspeed Vs. Density Altitude

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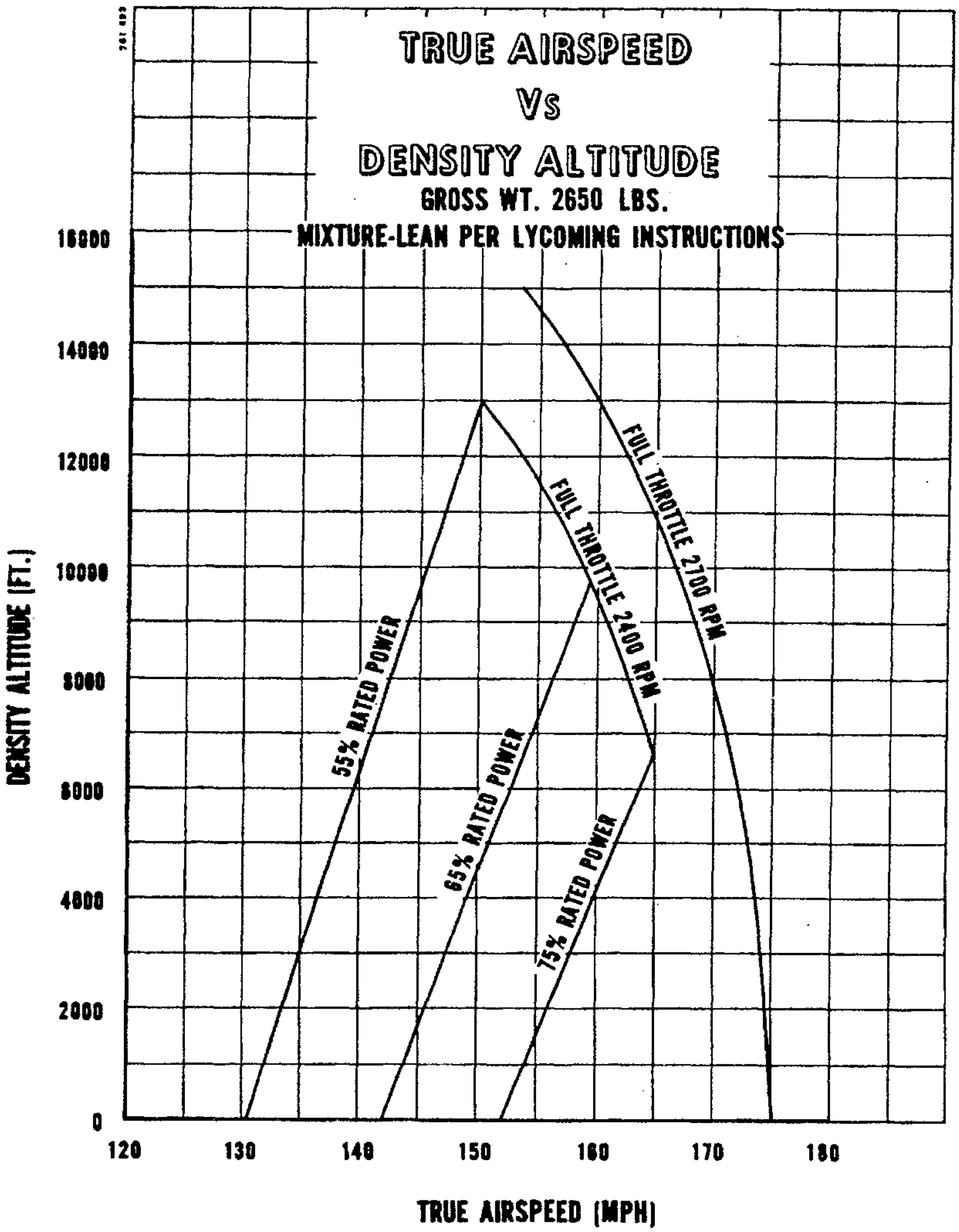

Range Vs. Density Altitude

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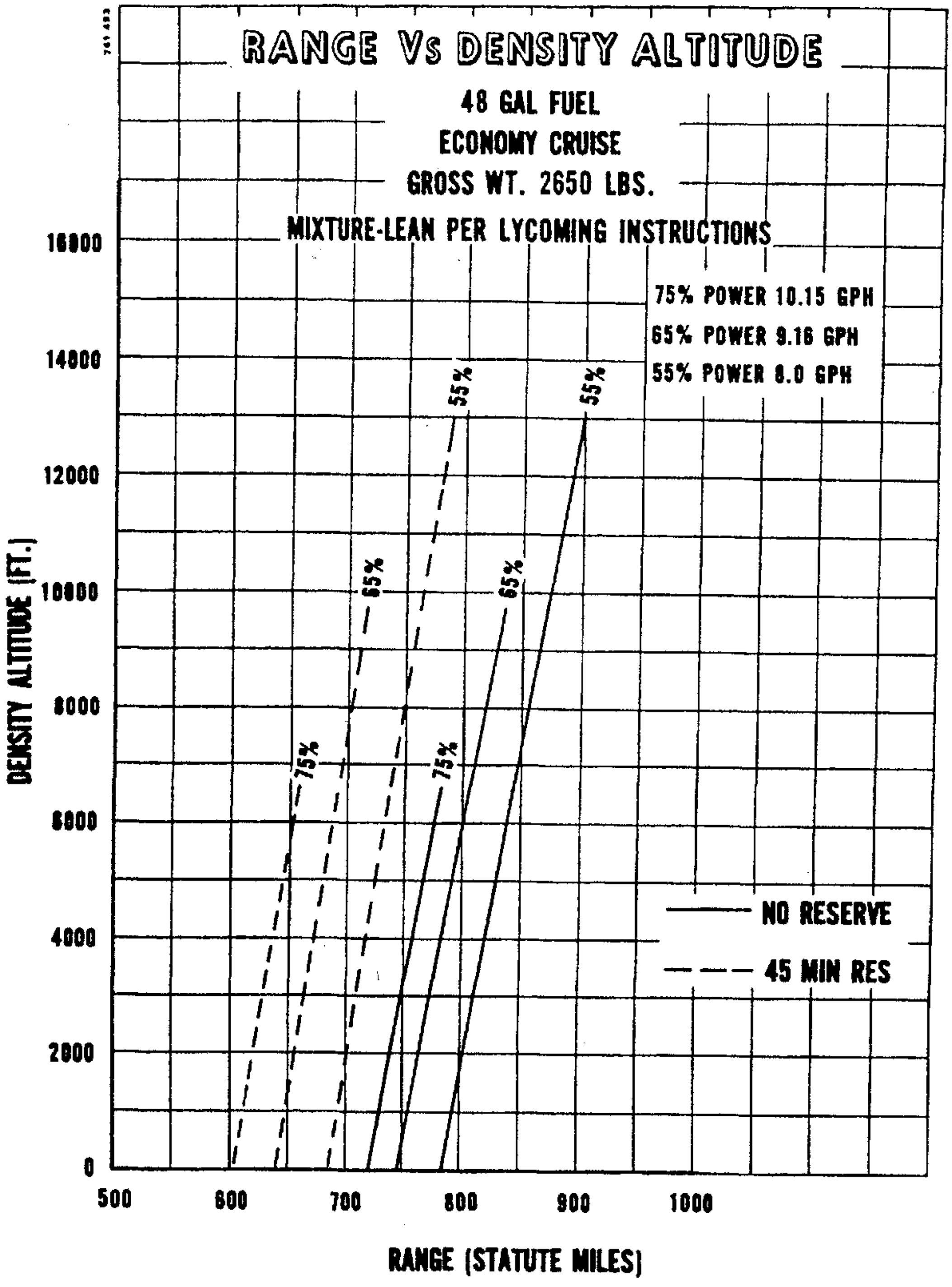

Landing Distance Vs. Density Altitude

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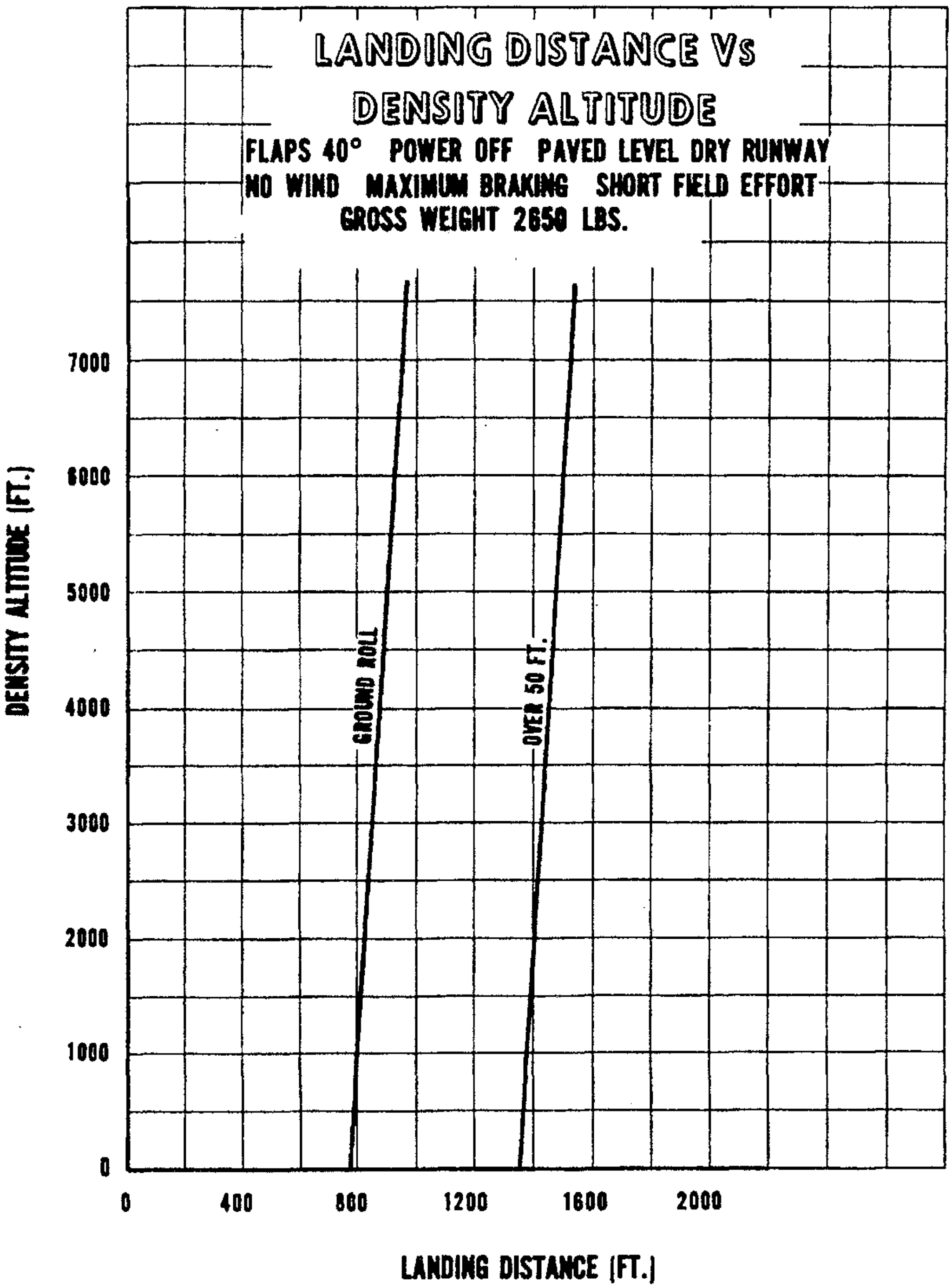

Glide Distance Vs. Altitude

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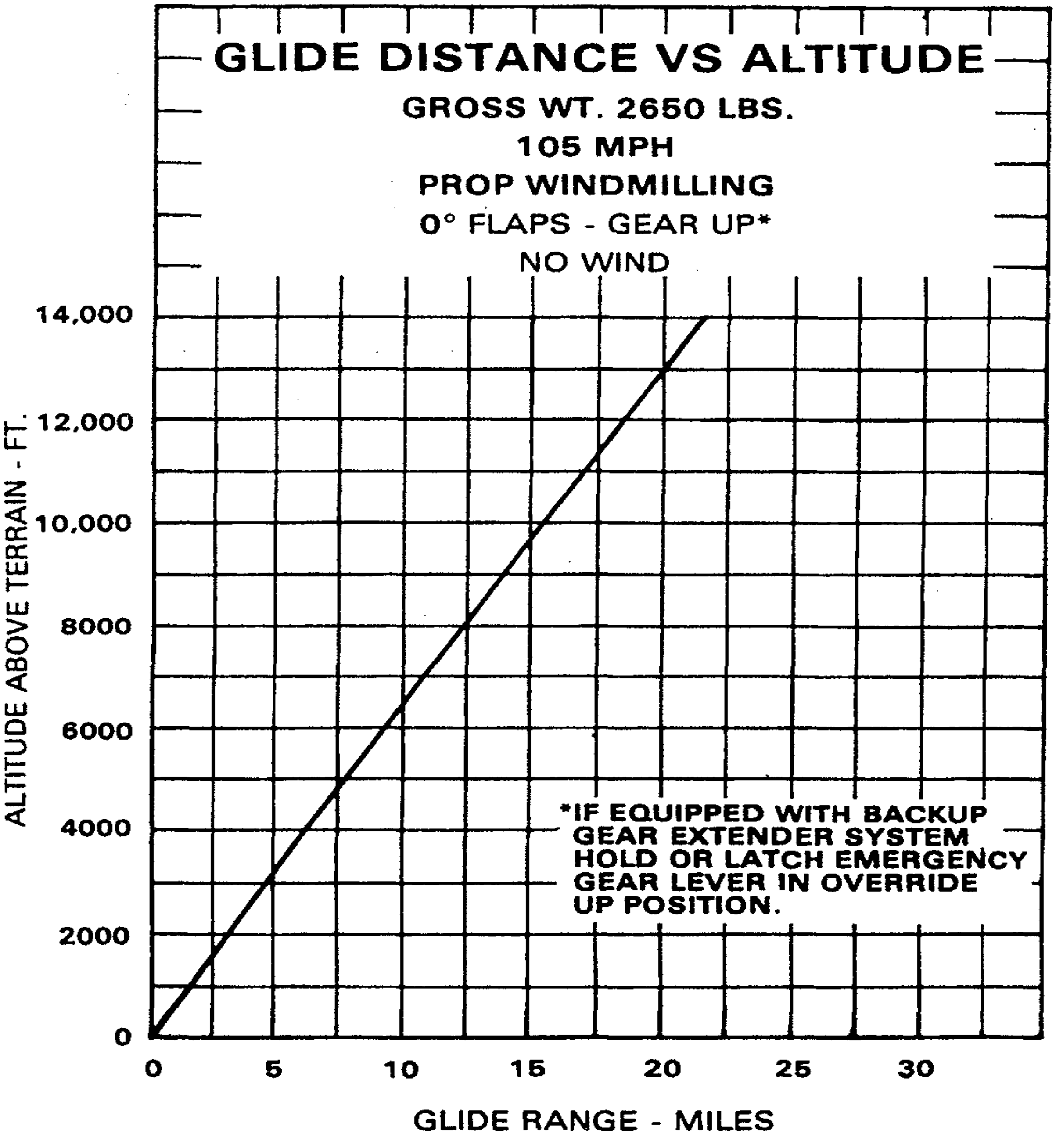

Power Setting Table

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Power Setting Table – Lycoming Model IO-360-C Series, 200 HP Engine

Press. Alt Feet	Std. Alt Temp ° F	110 HP – 55% Rated RPM AND MAN. PRESS 2100	110 HP – 55% Rated RPM AND MAN. PRESS 2400	130 HP – 65% Rated RPM AND MAN. PRESS 2100	130 HP – 65% Rated RPM AND MAN. PRESS 2400	150 HP – 75% Rated RPM AND MP 2400	Press. Alt Feet
	59	22.9	20.4	25.9	22.9	25.5	SL
1,000	55	22.7	20.2	25.6	22.7	25.2	1,000
2,000	52	22.4	20.0	25.4	22.5	25.0	2,000
3,000	48	22.2	19.8	25.1	22.2	24.7	3,000
4,000	45	21.9	19.5	24.8	22.0	24.4	4,000
5,000	41	21.7	19.3	FT	21.7	FT	5,000
6,000	38	21.4	19.1	—	21.5	—	6,000
7,000	34	21.2	18.9	—	21.3	—	7,000
8,000	31	21.0	18.7	—	21.0		8,000
9,000	27	FT	18.5	—	FT		9,000
10,000	23	—	18.3				10,000
11,000	19	—	18.1				11,000
12,000	16	—	17.8				12,000
13,000	12	—	17.6				13,000
14,000	9	—	FT				14,000

To maintain constant power, correct manifold pressure approximately 0.16" Hg for each 10° F variation in inlet air temperature from standard altitude temperature. Add manifold pressure for air temperatures above standard; subtract for temperatures below standard.