U.S. Department
of Transportation
Federal Aviation
Administration

Advisory Circular

Subject: RUNWAY LENGTH REQUIREMENTS FOR AIRPORT DESIGN
Date: 1/29/90
Initiated by: AAS-110
AC No: 150/5325-4A
Change:

1. PURPOSE. This advisory circular (AC) provides design standards and guidelines for determining recommended runway lengths.

2. CANCELLATIONS. This advisory circular cancels the following documents:

a. AC 150/5325-3, Background Information on the Aircraft Performance Curves for Large Airplanes, dated November 14, 1967.

b. AC 150/5325-4, Runway Length Requirements for Airport Design, dated September 27, 1978.

3. APPLICATION. The standards and guidelines contained in this advisory circular are recommended by the Federal Aviation Administration (FAA) for use in the design of civil airports. For airport projects receiving Federal grant-in-aid assistance, the use of these standards is mandatory.

Leonard E. Mudd
Director, Office of Airport Safety and Standards

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CHAPTER 1. INTRODUCTION

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CHAPTER 1. INTRODUCTION

1. BACKGROUND. Today's fleet of airplanes requires a wide range of runway lengths under a variety of environmental conditions. A few of the more obvious conditions which will alter the recommended runway lengths are airport elevation, aircraft operating weight, and runway surface conditions. This advisory circular (AC) provides guidelines for determining the appropriate length for a runway or runways. The aircraft performance data contained in this AC are for the design of airport runways and are not a substitute for calculations required by airplane operating rules.

2. PRIMARY RUNWAYS. The recommended length for the primary runway is determined by considering either the family of airplanes having similar performance characteristics or a specific airplane needing the longest runway. In either case, the choice should be based on airplanes that are forecasted to use the runway on a regular basis. A regular basis is considered to be at least 250 operations a year. Under very unusual circumstances, adjustments to this minimum frequency of operations may be made after considering the circumstances, e.g., seasonal traffic variations or the special needs of isolated or remote areas.

a. Airplanes Up To and Including 60.000 Pounds (27 200 kg). When the maximum gross weight of airplanes forecasted to use the runway is 60,000 pounds (27 200 kg) or less, the runway length should be designed for a family of airplanes. Chapter 2 contains guidelines for determining the appropriate runway length for a family or group of airplanes.

b. Airnlanes over 60.000 Pounds (27 200 kg) When the maximum gross weight of airplanes forecasted to use the runway is over 60,000 pounds (27 200 kg), the runway length is normally designed for a specific airplane. The recommended runway length for a specific airplane is a function of that airplane's landing and takeoff operating weights, the wing flap settings, the airport elevation and temperature, the runway surface conditions, and the maximum difference in runway centerline elevations. Chapter 2 contains the guidelines for determining the approximate length for the family or group of airplanes over 60,000 pounds (27 200 kg). Chapter 3 contains the guidelines for determining the appropriate runway length for specific airplanes.

3. OTHER RUNWAYS.

a. Crosswind Runways. A crosswind runway should have a length of at least 80 percent of the primary runway length.

b. Parallel Runways. Parallel runways should have a length based on the airplanes which will use the runways. Parallel runways should be approximately equal in length.

4. RUNWAY LENGTH BASED ON DECLARED DISTANCE CONCEPT. Runways are normally fully usable in both directions. Furthermore, they normally have clear approaches and departures to each runway end and do not have clearways or stopways. The "declared distance" concept outlined in AC 150/5300-13, Airport Design, is the design alternative for runways not fully usable for landing and takeoff in both directions, where approaches or departures to either runway end are obstructed, or a clearway or stopway is provided. Declared distances to be provided are:

a. Landine Runway Length. Landing distance available (LDA) should be at least equal to the landing runway length obtained from the design curves or tables.

b. Takeoff Runway Length.

(1) Reciprocating-Powered Airnlanes. Takeoff run available (TORA), accelerate-stop distance available (ASDA), and takeoff distance available (TODA) should be at least equal to the takeoff runway length obtained from the design curves or tables.

(2) Turbine-Powered Airplanes.

(a) TORA and ASDA may be up to 800 feet (240 m) shorter than the takeoff runway length obtained from the design curves or tables.

(b) TODA should be at least:

1 200 feet (60 m) longer than the takeoff runway length obtained from the design curves when ASDA is less than the takeoff runway length obtained from the design curves or tables, or

2 equal to the takeoff runway length obtained from the design curves when ASDA is equal to or greater than the takeoff runway length obtained from the design curves or tables.

5. COMPUTER PROGRAM. The Airport Design software cited in appendix 11 of AC 150/5300-13, Airport Design, may be used to quickly determine the recommended runway length for airport design. The nearest FAA Airports office can provide more details on the availability of the airport design software.

CHAPTER 2. RUNWAY LENGTH BASED ON AIRPLANE GROUPINGS

6. DESIGN GUIDELINES.

a. Approach Sneeds of less than 30 Knots. Airplanes with approach speeds less than 30 knots are considered short takeoff and landing or ultra-light aircraft. The recommended runway length is 300 feet (90 m) at sea level. Runway lengths above sea level should be increased at the rate of 30 feet (9 m) per 1,000 feet (300 m) of elevation.

b. Approach Speeds of 30 Knots or more but less than 50 Knots. The recommended runway length is 800 feet (240 m) at sea level. Runway lengths above sea level should be increased at the rate of 80 feet (24 m) per 1,000 feet (300 m) of elevation.

A)
12.5% Pounds (5 670 kg) or less. Figures 2-1 and 2-2 provide the recommended runway length based on the seating capacity. These runway lengths are based on airplanes without modifications. At airports above 5,000 feet (1 524 m), the airplanes are normally modified for higher altitudes to reduce their runway length requirements. Therefore, at sites above 5,000 feet the requirements for modified airplanes should be examined for less runway length.

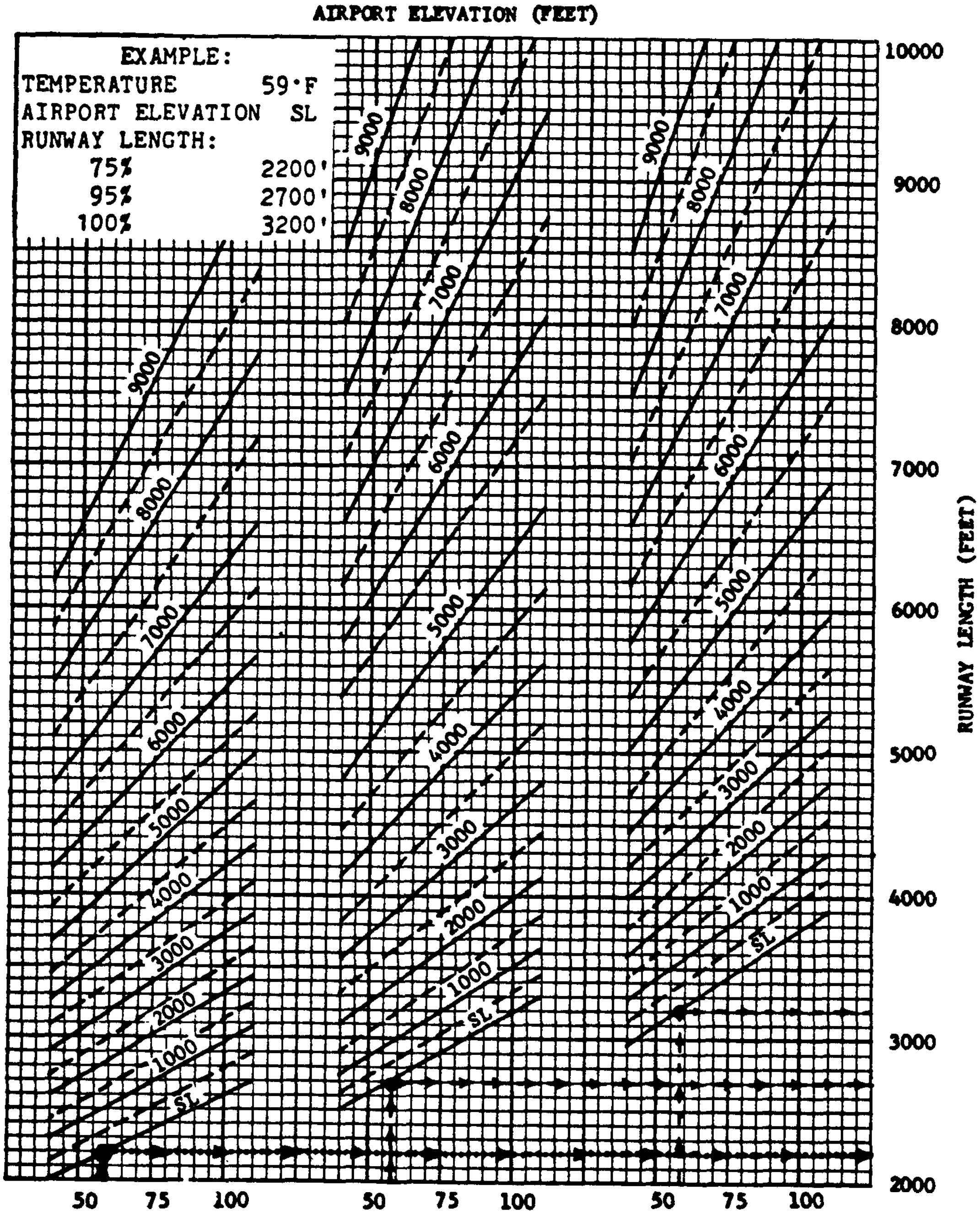
d. All Airplanes with Maximum Certificated Takeoff Weight of more than 12,500 Pounds (5 670 kg) and upto and including 60,000 Pounds (27 200 kg). Figures 2-3 and 2-4 are subdivided by the percentage of this family (75 or 100 percent) and the percentage of useful load (60 or 90 percent). Useful load is the difference between the airplane's maximum certificated takeoff weight and its operating empty weight.1/

(1) Examnles. Airplanes that make up 75 percent of the fleet are:

Manufacturer	Model
Gates Lear jet Corporation	Lear jet (20, 30, 50 series)
Rockwell International	Sabreliner (40, 60, 75, 80 series)
Cessna Aircraft	Citation (II, III)
Dassault - Breguet	Fan Jet Falcon (10, 20, 50 series)
British Aerospace Aircraft Corporation	HS-125 (400, 600, 700 series)
Israel Aircraft Industries	1124 Westwind

(2) Adiustments. The runway lengths obtained from figures 2-3 and 2-4 may require an increase for the maximum difference of runway centerline elevations or wet and slippery runway surface conditions. These increases are mutually exclusive since the first applies to takeoffs and the latter to landings. When runway length increases are needed for both conditions, only the larger of the two applies.

1/ The operating weight empty typically includes the airplane's empty weight, crew, crew's baggage and supplies, removable passenger service equipment and emergency equipment, engine oil, and unusable fuel. Thus, passengers and baggage, cargo, and usable fuel comprise the useful load.



MEAN DAILY MAXIMUM TEMPERATURE (F"), HOTTEST MONTH OF YEAR

75% OF FLEET 95% OF FLEET 100% OF FLEET

Figure 2-l. Runway length to serve small airplanes having less than 10 passenger seats

REPRESENTATIVE AIRPLANES			RUNWAY LENGTH CURVES
Beech	B80	m e - -	**EXAMPLE:**
Beech	E90	King Air	TEMPERATURE 59°F (15°C)
Beech	B99	Airliner	AIRPORT ELEVATION SEA LEVEL
Beech	A100	King Air	GEN. UTILITY 3700' (1 128 m)
Britten-Norman	Mark III-I	Trilander	Note: For airport elevations above 3000 feet (914 m) use the 100% curve, flqure 3.
Mitsubishi	MU-2L		
Swearigen	Merlin III-A		
Swearigen	Merlin IV-A		
Swearigen	Metro II		

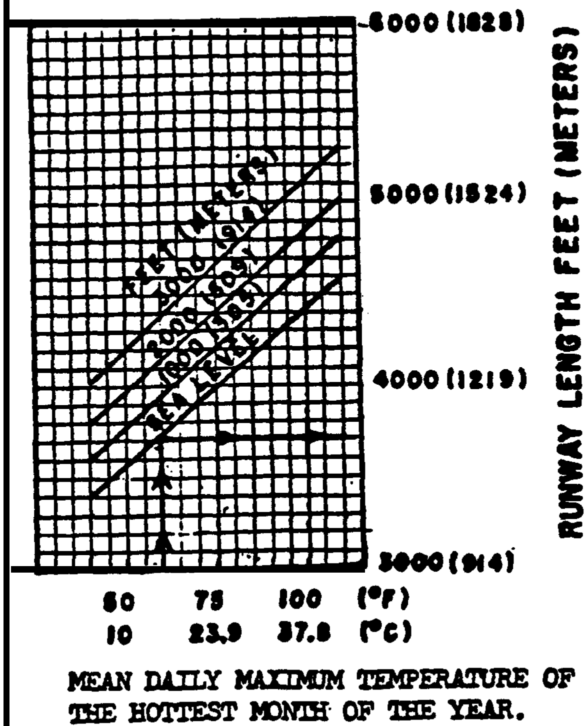


Figure 2-2. Runway length to serve small airplanes having 10 passenger seats or more

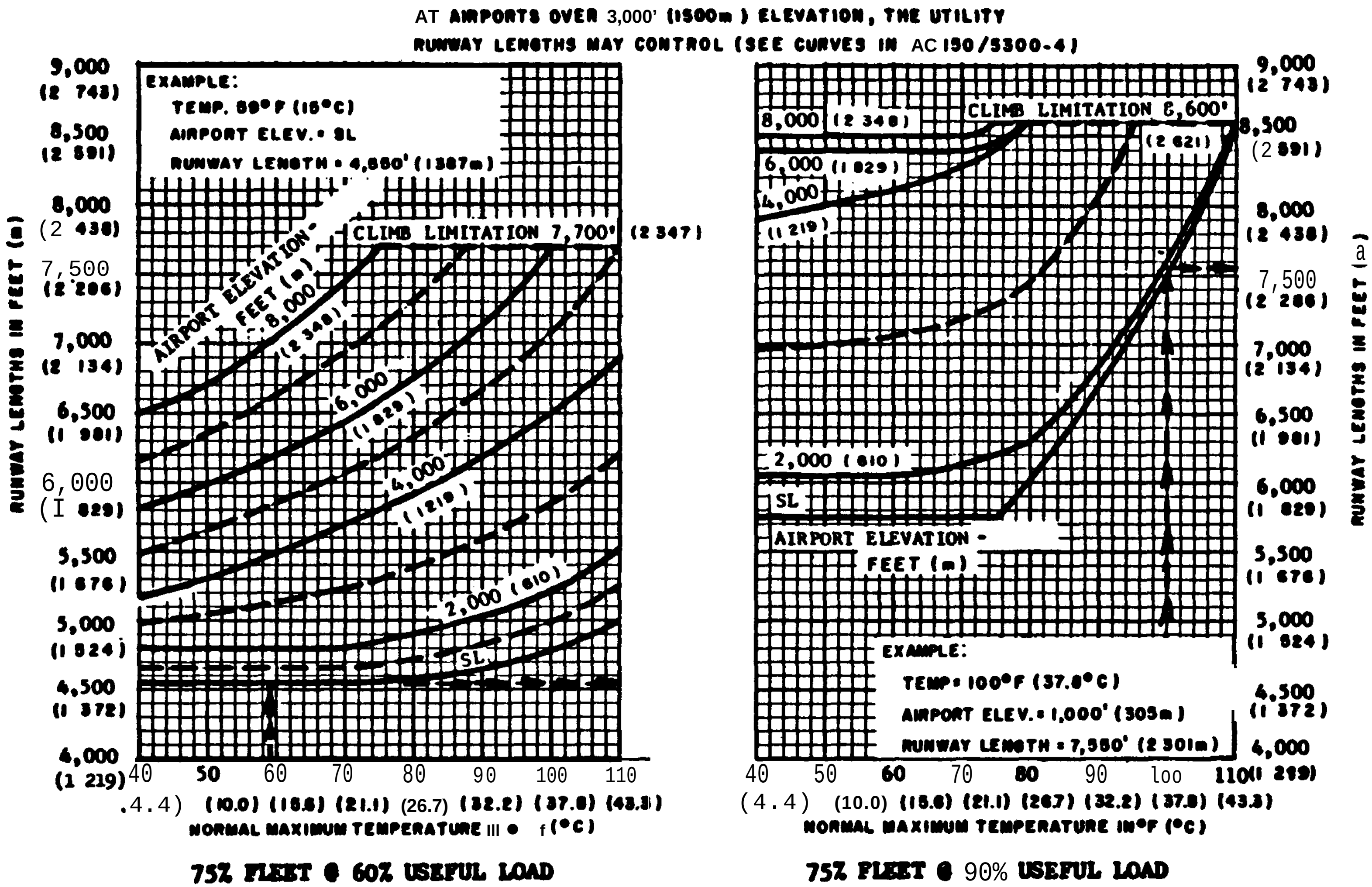


Figure 2-3. **Runway** length to serve **75% of** large airplanes **of** 60,000 pounds **(27** 200 **kg) or** less

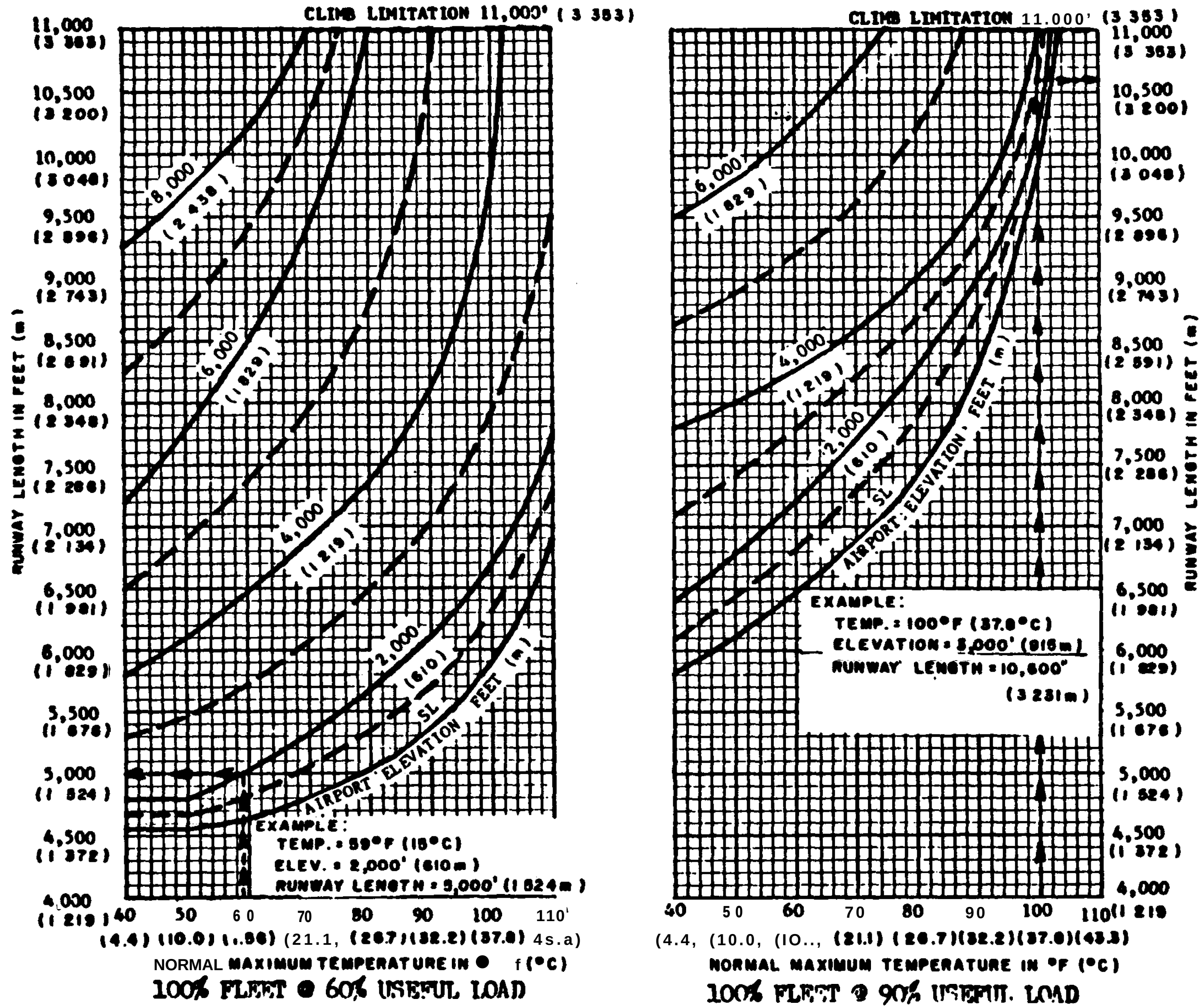


Figure 2-4. **Runway length** to serve **100%** of large airplanes *of 60,000 pounds (27 200* kg) or **less**

(a) Difference in Runway Centerline Elevations. Runway lengths taken from the curves are increased at the rate of 10 foot (3 m) for each foot (0.3 m) of elevation difference between the high and low points of the runway centerline.

(b) Wet and Slippery Runways (turbojet-Dowered airplanes). Runway lengths taken from the 60 percent useful load curves are increased by 15 percent, or up to 5,500 feet (1 680 m), whichever is less. Runways lengths obtained from the 90 percent useful load curves are increased by 15 percent, or up to 7,000 feet (2 130 m), whichever is less.

(c) High Altitude Locations. At elevations above 5,000 feet (1 500 m) mean sea level, the runway length for airplanes of 12,500 pounds (5 670 kg) or less maximum certificated takeoff weight may be greater than those required for those turbojet-powered airplanes. In these cases, the longer length should be provided.

e. All Airplanes with Maximum Certificated Takeoff Weight of more than 60,000 Pounds (27 200 kg). Figure 2-5 illustrates the pattern that exists between runway length and length of haul. Runway lengths up to 15,000 feet (4 900 m) may be taken as an approximation of the recommended runway length.

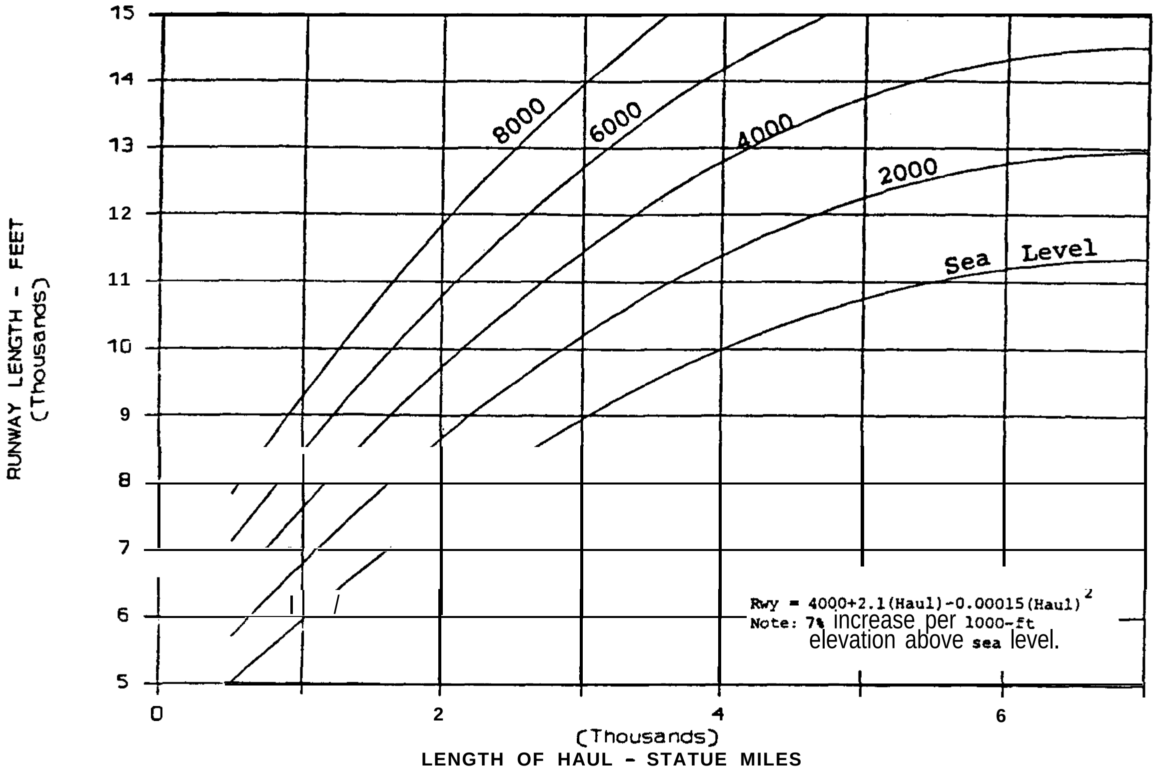


Figure 2-5. General runway length planning guide

CHAPTER 3. RUNWAY LENGTH BASED ON SPECIFIC AIRPLANES

7. DESIGN GUIDELINES. This design procedure uses the curves of appendices 1 and 2 and the tables of appendix 3. Appendix 1 is for piston- and turboprop-powered airplanes and appendixes 2 and 3 are for turbojet-powered airplanes. Section 1 is the procedure for using the curves and section 2 is the procedure for using the tables. Both landing and takeoff lengths must be computed with the longer length being the recommended runway length.

SECTION 1. AIRPLANE PERFORMANCE CURVES

8. REQUIRED INFORMATION. The following basic information must be gathered for use with the curves:

a. The airplanes which are to be served.

b. The mean daily maximum temperature ('F) for the hottest month of the year at the airport.

c. The airport elevation (MSL).

d. The longest length of haul flown on a regular basis.

e. The maximum difference in runway centerline elevation.

9. INTERPOLATION. Interpolation is permissible and usually necessary between curves for airport temperatures, airport elevations, and airplane operating weights.

10. EXAMPLE NO. 1. This example (figure 3-2 trace) illustrates how limitations on the curves apply at heavy operating weights, high elevations, and/or high temperatures. These limitations are indicated by the "limit lines" and "elevation lines" in the upper right-hand portion of the takeoff performance curves.

a. Problem. Determine the recommended runway length for the following airplane design conditions:

(1) Airplane . . . . . Example Large Airplane (figures 3-1 and 3-2).

(2) Mean daily maximum temperature . . . . 70°F.

(3) Airport elevation . . . . 3,000 feet.

(4) Length of Haul . . . . 2,200 Miles.

(5) Maximum difference in runway centerline elevations . . . 56 feet.

b. Landine Leneth. This length is derived from figure 3-1 as follows:

(1) Enter the figure on the abscissa (horizontal) axis at the airplane's maximum landing weight (175,000 pounds) (see paragraph 17).

(2) Project this point vertically to the intersection with the slanted line corresponding to the airport's elevation (3,000 feet).

(3) Extend this point of intersection horizontally to the right to the intersection with the runway length scale to 6,900 feet.

(a) If the airplane is piston- or turboprop-powered (appendix 1), the landing length is 6,900 feet,

(b) If the airplane is turbojet-powered (appendix 2), increase the landing length by 7 percent, i.e., 6,900 x 1.07 or 7,390 feet (see paragraph 21).

c. Takeoff Length. This length is derived from figure 3-2 as follows:

(1) Enter the temperature scale on the abscissa (horizontal) axis at the temperature (70" F).

(2) Project this point vertically to the intersection with the slanted line corresponding to the airport's elevation (3,000 feet).

(3) Extend this point of intersection horizontally to the right until coincident with the reference line (RL).

(4) Proceed up and to the right or down and to the left, interpolating between the slanted lines as necessary, to the intersection of either the elevation limit line (3,000-foot) or the point directly above the airplane's takeoff weight or distance (2,200 miles), whichever yields the shortest runway length. In this case the 3,000-foot elevation limit line yields the shortest length.

(5) Project this point horizontally to the right to the intersection with the runway length scale to read 11,250 feet.

(6) Increase this runway length for the maximum difference in runway centerline elevations. Add 560 feet (56 ft x 10, see paragraph 22) to obtain 11,810 feet.

d. Answer. For this example, the recommended runway length is the takeoff length (11,800 feet) since it is greater than the landing length. Runway lengths of 30 feet and over are rounded up to the next 100-foot interval.

EXAMPLE LARGE AIRPLANE

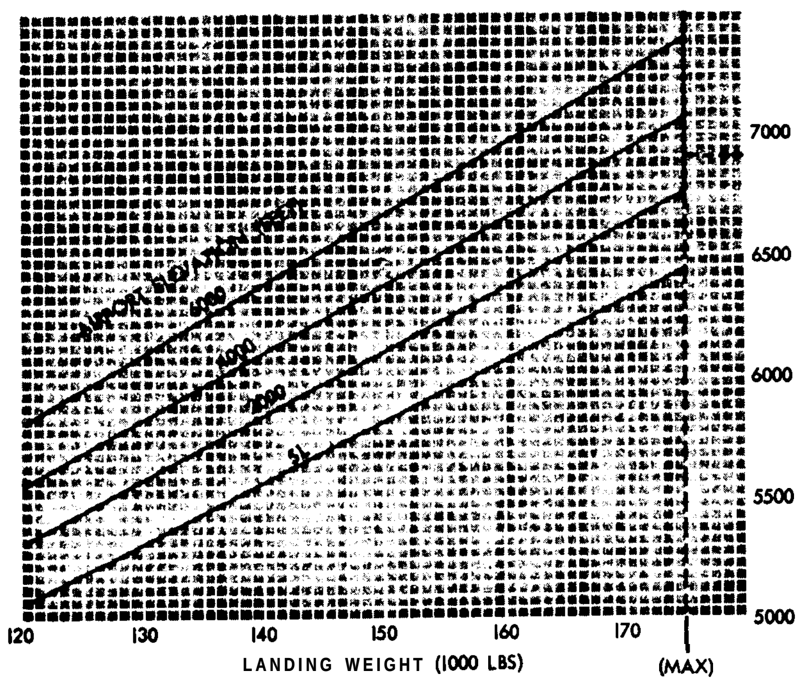


Figure 3-1. Airplane performance curve: landing (example)

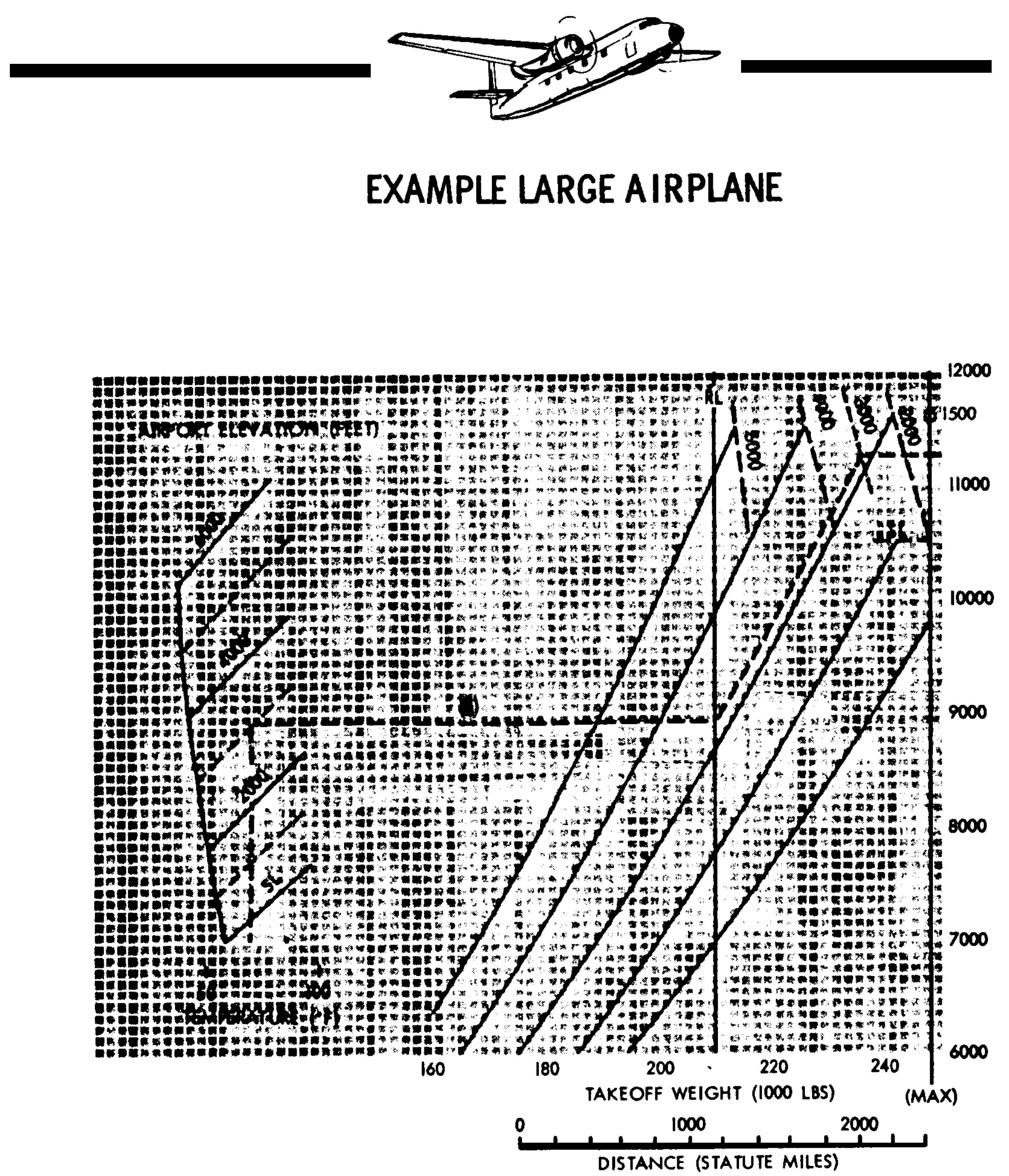


Figure 3-2 Airplane performance curve takeoff (example)

SECTION 2. AIRPLANE PERFORMANCE TABLES

11. REQUIRED INFORMATION. The following basic information must be gathered for use with the tables:

a. The airplanes which are to be served.

b. The mean daily maximum temperature ("F) for the hottest month of the year at the airport.

c. The airport elevation (MSL).

d. The longest length of haul flown on a regular basis.

e. The selected payload.

f. The maximum difference in runway centerline elevation.

12. INTERPOLATION.

a. Flap Settings. Flap settings shown in the tables are the authorized settings for operations. No interpolation is made between flap settings.

b. Other Factors. Interpolation is permissible and usually necessary between airport temperature, airport elevation, airplane operating weight, and the reference factor "R".

13. EXAMPLE NO. 2.

a. Problem. Determine the recommended runway length for the following design conditions:

(1) Airplane . . Boeing 707-303C (JT3D-3B Engine) Convert, Passenger.

(2) Mean daily maximum temperature . . . . 85°F.

(3) Airport elevation . . . . 3,000 Feet.

(4) Length of haul . . . . , . . . , . 1,200 Statute Miles.

(5) Selected payload . . . . 74,900 Pounds.

(6) Maximum difference in runway center elevations . . . . . 48 Feet.

b. Landing Length. This length is derived from table 1, appendix 3, as follows.

(1) Enter the table with a temperature of 85°F and an airport elevation of 3,000 feet. Read a maximum allowable landing weight of 247,000 pounds. Repeat for each flap setting for airplanes with data for more than one flap setting. Identify the flap setting(s) that provides the greatest maximum allowable landing weight.

(2) Enter the runway length section of the table for this flap setting(s) with the maximum landing weight of 247,000 pounds and the airport elevation of 3,000 feet and read the runway length of 7,646 feet through interpolation. The landing length is rounded up to 7,700 feet. When there are two or more flap settings yielding the greatest maximum" allowable landing weight, the landing length is the shortest runway length obtained from any of these flap settings.

c. Takeoff Weight. Calculate the takeoff weight using the information found at the bottom of table 1, appendix 3, and top of table 2, appendix 3, as follows:

(1) Multiply the length of haul by the average fuel consumption to obtain the fuel weight for this length of haul.

1,200 statute miles
x 27 pounds/mile
32,400 pounds

(2) To this fuel weight, add the typical operating empty weight and the reserve fuel weight to obtain the airplane weight without payload. A few tables have two typical operating empty weight plus reserve fuel entries. In these cases, use the entry based on 1.25 hours of reserve fuel.

32,400 pounds
+ 171.100 pounds
203,500 pounds

(3) To this weight, add the payload (for this example equals the maximum structural payload).

203,500 pounds
+ 74,900 pounds
278,400 pounds

(4) Enter the top of table 2 with a temperature of 85°F and an airport elevation of 3,000 feet. Read a maximum allowable takeoff weight of 311,400 pounds. Repeat for each flap setting for airplanes with data for more than one flap setting. Identify the flap setting(s) that accommodates the above weight of 278,400 pounds. If none, then identify the flap setting(s) which produces the greatest maximum allowable takeoff weight. The takeoff weight is 278,400 pounds at the flap setting listed at top of table 2 for this example. The 278,400 pounds controls since it is less than the maximum allowable takeoff weight of 311,400 pounds.

d. Takeoff Length. This length is derived from table 2, appendix 3, as follows:

(1) Enter the Reference Factor "R" section of the table with a temperature of 85°F and an airport elevation of 3,000 feet to read a value of "R" = 82.9.

(2) Enter the runway section of the table with the takeoff weight of 278,400 pounds and the R value of 82.9 to read a takeoff runway length of 9,620 feet by interpolation. When there are two or more flap settings yielding the design takeoff weight, the takeoff length is the shortest runway length obtained from any of these flap settings. This takeoff length is for zero wind and zero difference in runway centerline elevations.

(3) Adjustment for maximum difference between runway centerline elevations per paragraph 22:

9,620 + (48 x 10) = 9,620 + 480 = 10,100 feet

(4) Answer.

Landing Weight	247,000 pounds
Takeoff Weight	278,400 pounds
Landing Length	7,700 feet
Takeoff Length	10,100 feet

The recommended runway length for this airplane is 10,100 feet. Runway lengths of 30 feet and over are rounded up to the next 100-foot interval.

Chapter 4. DESIGN RATIONALE

14. INTRODUCTION. This chapter provides guidance on the application of eight of the variable factors that significantly affect the recommended runway length. All other variable factors are incorporated into the curves and tables of this advisory circular in a manner to produce the shortest recommended runway length. Therefore, the recommended runway length can be obtained from airplane flight manuals by applying the eight variable factors as discussed in this chapter and applying all other factors in a manner to produce the shortest runway length, e.g., "braking anti-skid" is activated, Table 4-1 summarizes the eight variable factors.

15. AIRPLANE. The recommended runway length is based on the airplanes forecasted to use the runway on a regular basis. A regular basis is considered to be at least 250 operations a year. Under very unusual circumstances, adjustments to this minimum frequency of operations may be made after considering the circumstances, e.g., seasonal traffic variations or the special needs of isolated or remote areas.

16. FLAP SETTINGS. The recommended runway length is based on the flap setting producing the shortest runway length. Composite figures 2-1 through 2-4 and appendices 1 and 2 are based on the flap settings that produce this length. Appendix 3 lists the authorized flap settings at the top of each series of landing and takeoff tables. Therefore, when using appendix 3, select the flap setting producing the shortest runway length.

17. OPERATING WEIGHTS. The recommended runway length is based on realistic operating weights. These weights are normally the operating weights of airplanes conducting regular operations over a specific length of haul. For landing runway length design, this weight is the maximum allowable landing weight, excluding subparagraph 17a(3). For takeoff runway length design, this weight is the lesser of (1) the operating weight empty plus the weight of the reserve fuel, weight of fuel required to fly to the airport of destination, and payload, (2) the airplane's maximum structural landing weight plus the weight of fuel required to fly to the airport of destination, or (3) the maximum allowable takeoff weight, excluding subparagraph 17b(6). Justification for lengthening a runway beyond that required for these maximum allowable operating weights must be for other than increased operating weights.

a. Maximum Allowable Landine Weight. The airplane's maximum allowable landing weight is the lesser of the following:

(1) Maximum Structural Landing Weight.

(2) Climb Limited Landine Weight.

(3) Runwav Length Limited Landing Weight.

b. Maximum Allowable Takeoff Weight. The airplane's maximum allowable takeoff weight is the lesser of the following:

(1) Maximum Structural Takeoff Weight.

(2) Climb Limited Takeoff Weight.

(3) Tire Speed Limited Takeoff Weight.

FACTORS & Paragraph Reference		COMPOSITE CURVES: Figures 2-1, 2-2	COMPOSITE CURVES: Figures 2-3, 2-4	AIRPLANE PERFORMANCE CURVES: Appendix 1 Non-Turbojet	AIRPLANE PERFORMANCE CURVES: Appendix 2 Turbojet	AIRPLANE PERFORMANCE TABLES: Appendix 3 Turbojets over 12,500 lbs
Airplane Type (para. #15)		Based on Number of Passenger Seats	Based on Percent of Fleet	Indicated on Curves	Indicated on Curves	Indicated on Tables
Flap Settings (para. #16)		For Shortest Runway Length	For Shortest Runway Length	For Shortest Runway Length	For Shortest Runway Length	Indicated on Tables
Operating Weights (para. #17)	Takeoff	Maximum Takeoff Wt.	Percent of Useful Load	Indicated on Curves	Indicated on Curves	Indicated on Tables
	Landing	Maximum Takeoff Wt.	Percent of Useful Load	Indicated on Curves	Indicated on Curves	Indicated on Tables
Airport Elevation (para. #18)		Indicated on Curves	Indicated on Curves	Indicated on Curves	Indicated on Curves	Indicated on Tables
Temperature (para. # 19)	Takeoff	Indicated on Curves	Indicated on Curves	Indicated on Curves	Indicated on Curves	Indicated on Tables
	Landing	Indicated on Curves	Independent of Results	Independent of Results	Independent of Results	Independent of Results
Wind (para. #20)	Takeoff	Zero Wind	Zero Wind	Zero Wind	Zero Wind	Zero Wind
	Landing	Zero Wind	Zero Wind	Five Knots	Five Knots	Zero Wind
Runway Surface Conditions (para. #21)	Takeoff	Independent of Results	Independent of Results	Independent of Results	Independent of Results	Independent of Results
	Landing	Independent of Results	Dry	Independent of Results	Dry	Wet
Difference in Runway Centerline (para. #22)	Takeoff	Independent of Results	Zero	Zero	Zero	Zero
	Landing	Independent of Results	Independent of Results	Independent of Results	Independent of Results	Independent of Results
Runway Length for Takeoff		Airplane Takeoff Distance	Larger of Airplane Takeoff Distance or Accelerate-Stop Distance	Larger of Airplane Takeoff Distance or Accelerate-Stop Distance	Larger of Airplane Takeoff Distance or Accelerate-Stop Distance	Larger of Airplane Takeoff Distance or Accelerate-Stop Distance
Runway Length for Landing		Airplane Landing Distance	Airplane Dry Landing Distance Divided by 0.6	Airplane Landing Distance Divided by 0.6	Airplane Dry Landing Distance Divided by 0.6	If available, Airplane Wet Landing Distance Divided by 0.6 Otherwise, (Airplane Dry Landing Distance Divided by 0.6) x 1.15

Table 4-1. Treatment of design runway factors

(4) Takeoff Weight Limited by Maximum Landing Weight.

(5) Obstacle Clearance Limited Takeoff Weight.

(6) Runway Length Limited Takeoff Weight.

c. Operating Weights. The recommended runway length is based on the following:

(1) Small Airplanes. Composite figures 2-1 through 2-2 provide the recommended runway lengths for maximum allowable landing and takeoff weights.

(2) Laree Airplanes.

(a) Composite Fieures. Composite figures 2-3 and 2-4 provide the recommended runway lengths for the lesser of (1) the maximum allowable landing and takeoff weights or (2) the weight of the airplane with useful load.

(b) Appendices 1 and 2.

1 For landing runway length, use the maximum allowable landing weight, excluding subparagraph 17a(3).

2 For takeoff runway length, use the lesser weight of the maximum allowable takeoff weight, exclusive of subparagraph 17b(6), or the weight corresponding to the distance flown. The weight corresponding to the distance flown is the lesser of either (1) the operating weight empty plus 100 percent structural payload plus the weights of fuel required to fly to the airport of destination and fuel reserve required for one hour and 15 minutes of flying time or (2) the airplane's maximum structural landing weight plus the weight of fuel required to fly to the airport of destination.

(c) Appendix 3.

1 For landing runway length, use the maximum allowable landing weight, excluding subparagraph 17a(3).

2 For takeoff runway length, use the lesser of (1) the operating weight empty plus payload, plus fuel required to fly to the airport of destination, and plus the weight of the reserve fuel, (2) the airplane's maximum structural landing weight plus the weight of fuel required to fly to the airport of destination, or (3) the maximum allowable takeoff weight, excluding subparagraph 17b(6).

18. AIRPORT ELEVATION. For runway length design, substitute airport elevation above mean sea level for pressure altitude. This substitution is acceptable since the two are approximately equal and the probability of these conditions occurring simultaneously is relatively remote. Therefore, any difference can be discounted.

19. TEMPERATURE. For runway length design, use the mean daily maximum temperature at the airport during the hottest month of the year as the temperature. This temperature is readily available and yields a practical length.

20. WIND. The recommended runway length is based on zero wind velocity. Composite figures 2-1 through 2-4, the takeoff curves in appendices 1 and 2, and the tables in appendix 3 are based on zero wind velocity. The landing curves of appendices 1 and 2 are based on a five-knot tailwind. The runway lengths obtained from the landing curves of appendices 1 and 2 are converted to zero wind velocity as part of the calculations of compensation for runway surface conditions.

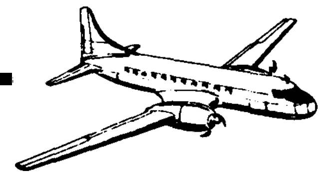
21. RUNWAY SURFACE CONDITIONS (LANDING ONLY). The recommended runway length is based on the most demanding runway conditions. For turbo-jet airplanes, this is when the runway is wet or slippery. Wet or slippery conditions require an increase in the turbo-jet airplane (dry) landing runway length. The landing length tables and figure 2-5 are based on wet or slippery runway conditions. The landing curves in appendix 2 and the landing portion of the curves in figures 2-3 and 2-4 are based on dry runway conditions. The landing lengths taken from the landing portions of figures 2-3 and 2-4 need to be increased by 15 percent. The curves in appendix 2 take into account a five-knot tailwind which reduces the increase to 7 percent. There is no operational requirement for an increase in runway length for wet or slippery conditions for other than turbo-jet airplane landings.

22. MAXIMUM DIFFERENCE OF RUNWAY CENTERLINE ELEVATION (TAKEOFF ONLY). The maximum difference of runway centerline elevation affects the recommended runway length. For airplanes over 12,500 pounds (5 670 kg) maximum certificated takeoff weight, the recommended takeoff runway lengths derived from composite figures 2-3 and 2-4 and appendices 1 though 3 must be increased by 10 feet per foot of difference in centerline elevation between the high and low points of the runway centerline elevations. This increase approximates the operational increase required for uphill effective runway gradient. There is no operational requirement for an increase in landing runway length to compensate for uphill or downhill effective runway gradient. There is no operational requirement for an increase in runway length to compensate for effective runway gradient for airplanes of 12,500 pounds (5 670 kg) or less maximum certificated takeoff weight. There is no need to increase the runway lengths derived from figure 2-5.

APPENDIX 1. PISTON- AND TURBOPROP-POWERED LARGE AIRPLANES

1. AIRPLANE PERFORMANCE CURVES. The data curves contained in this appendix are for large piston-powered airplanes (figures 1 - 34) and large turboprop-powered airplanes (figures 35 - 60).

2. EXPLANATORY INSTRUCTIONS. See chapter 2 for explanatory instructions on the use of the data curves.



CONVAIR 240

PRATT & WHITNEY R2800-CA18 ENGINE
R2800-CB16

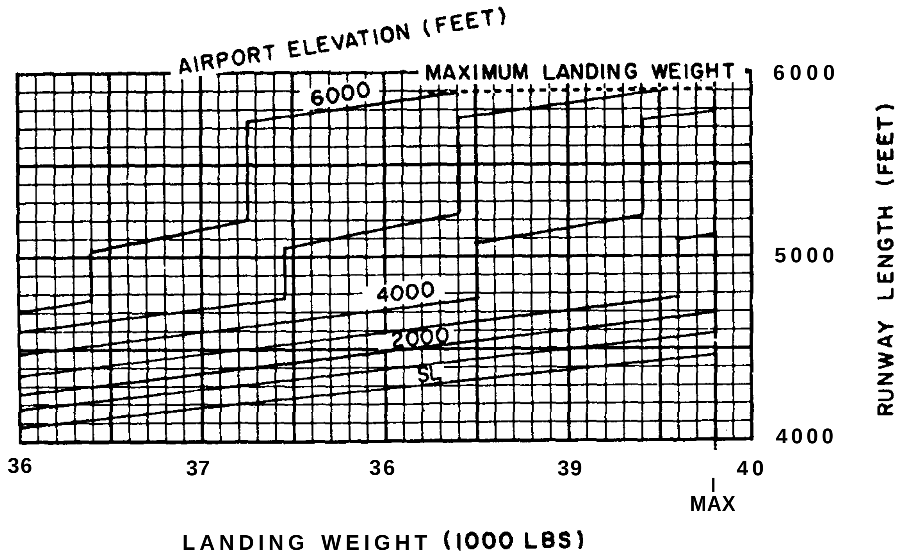


FIGURE 1. Aircraft Performance Curve, Landing (Convair 240)

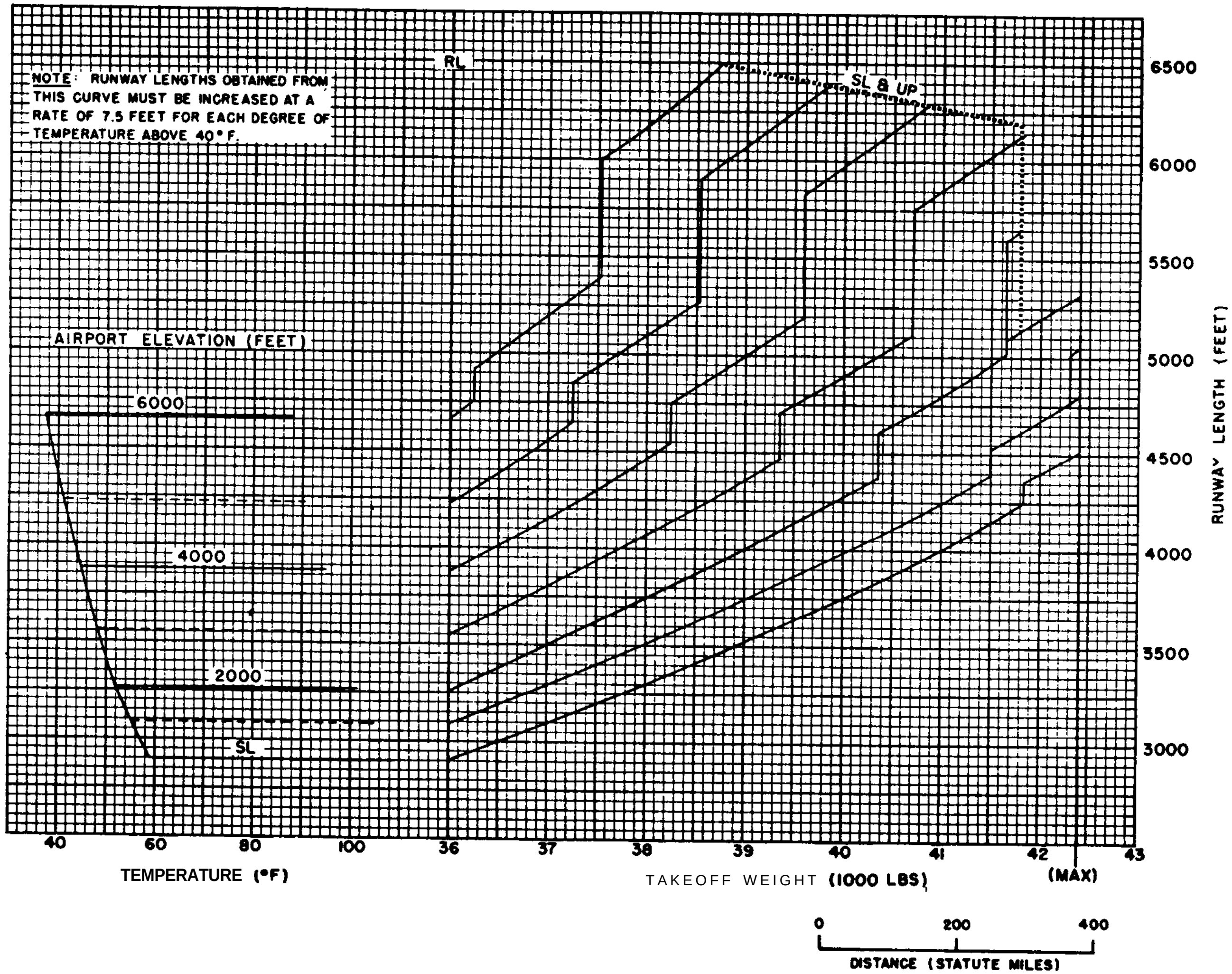
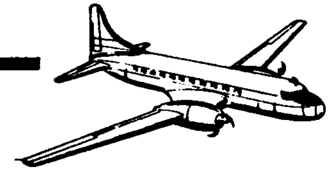


FIGURE 2. Aircraft Performance Curve, Takeoff (Convair 240)



CONVAIR 340 & 440

PRATT & WHITNEY **R2800-CB3** ENGINE
R2800-CB4
R2800-CB16
R2800-CB17

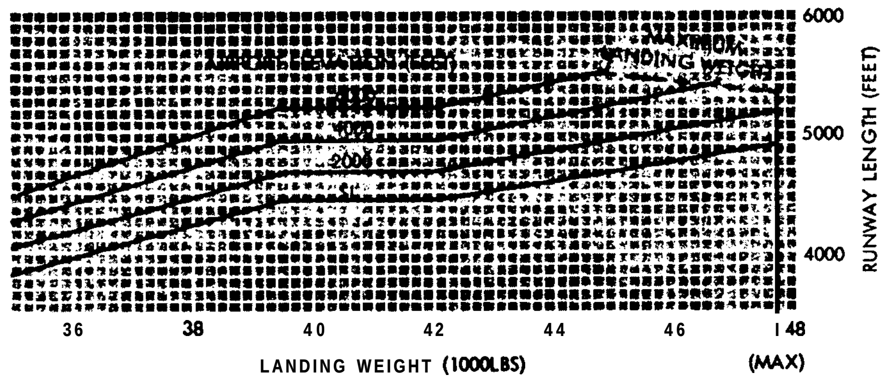


FIGURE 3. Aircraft Performance **Curve,** Landing (Convair 340 **& 440)**

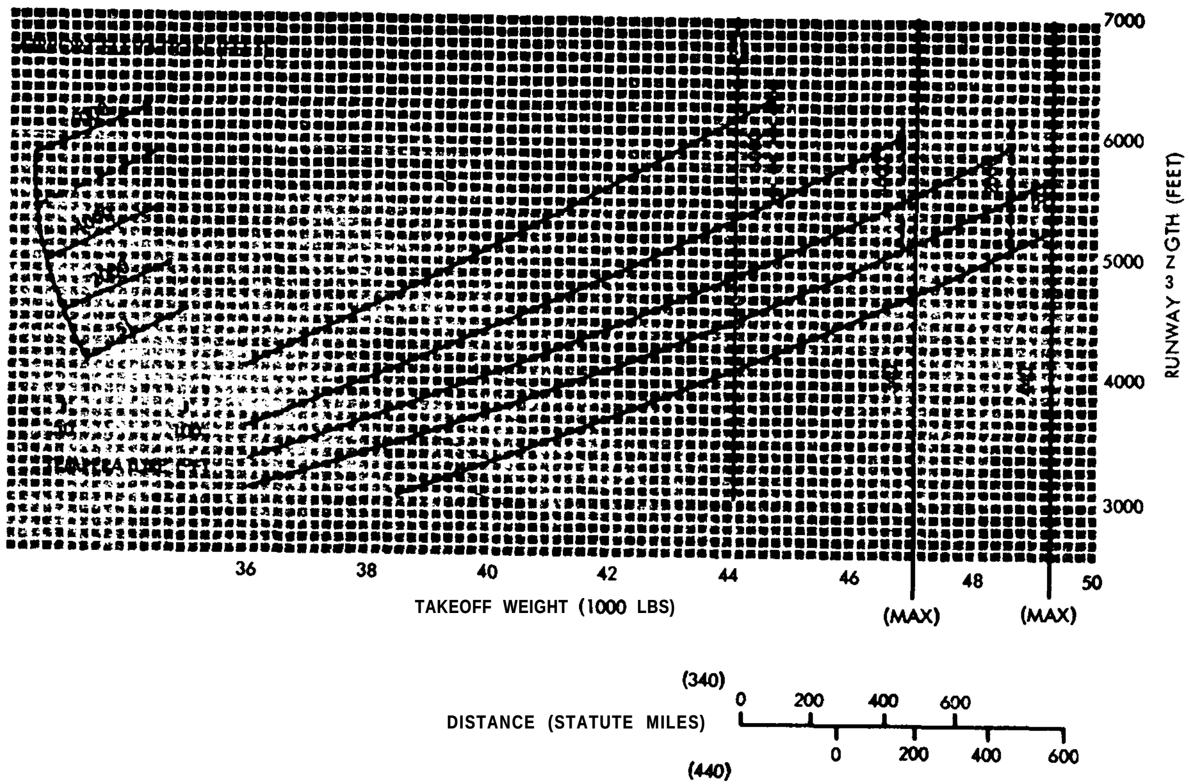
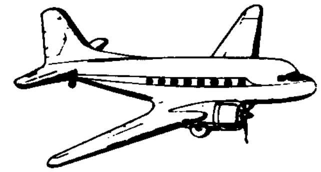


FIGURE 4. Aircraft Performance Curve, Takeoff (Convair 340 & 440)



DOUGLAS DC-3

NONTRANSPORT
PRATT & WHITNEY SIC 3G ENGINE
WRIGHT G-202A

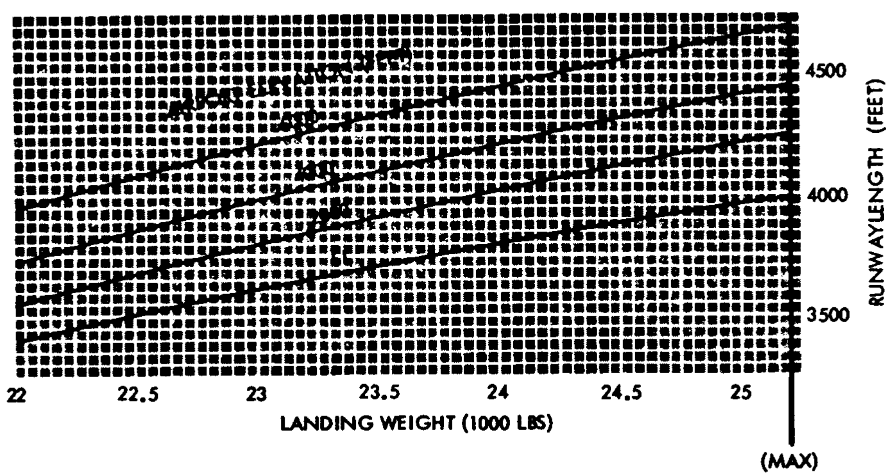


FIGURE 5. Aircraft Performance Curve, Landing (Douglas DC-3)

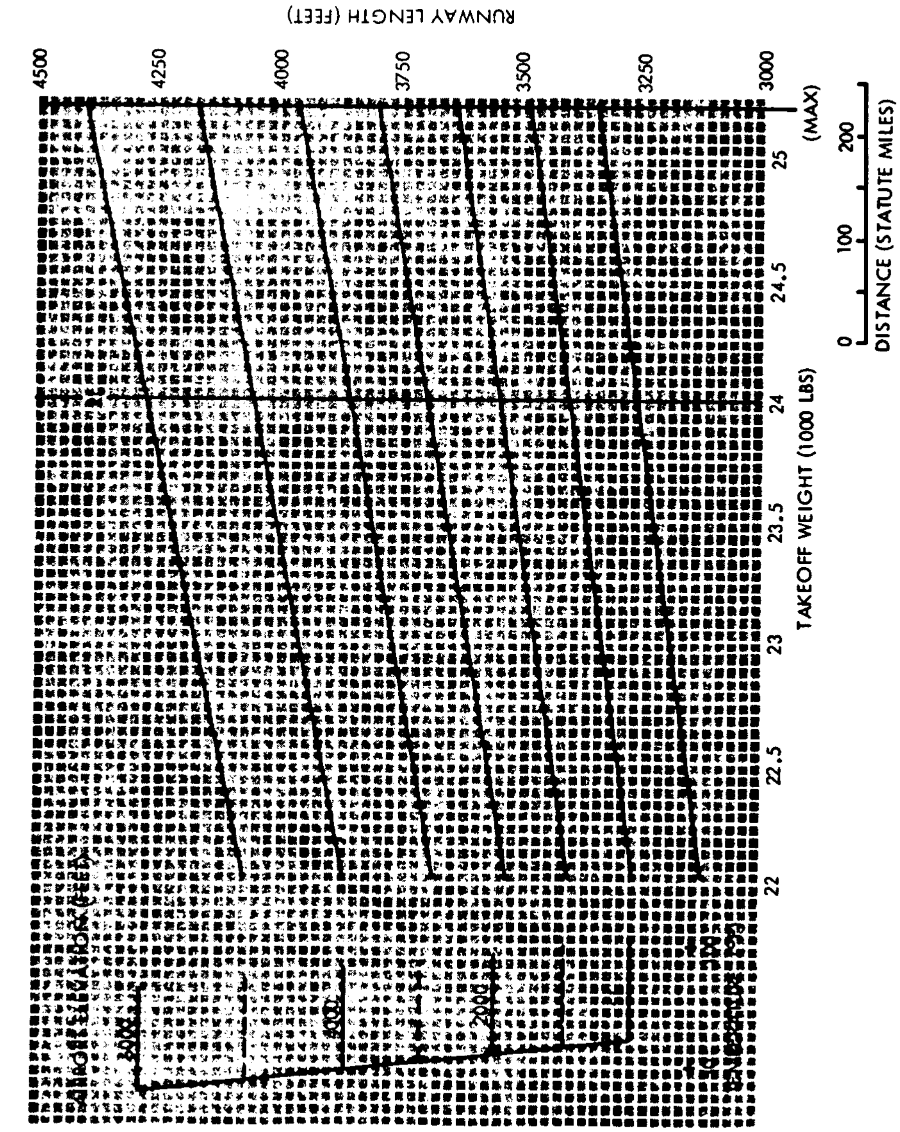


FIGURE 6. Aircraft Performance Curve, Takeoff (Douglas DC-3)

DOUGLAS DC-4

PRATT & WHITNEY R2000-7 ENGINE
R2000-11

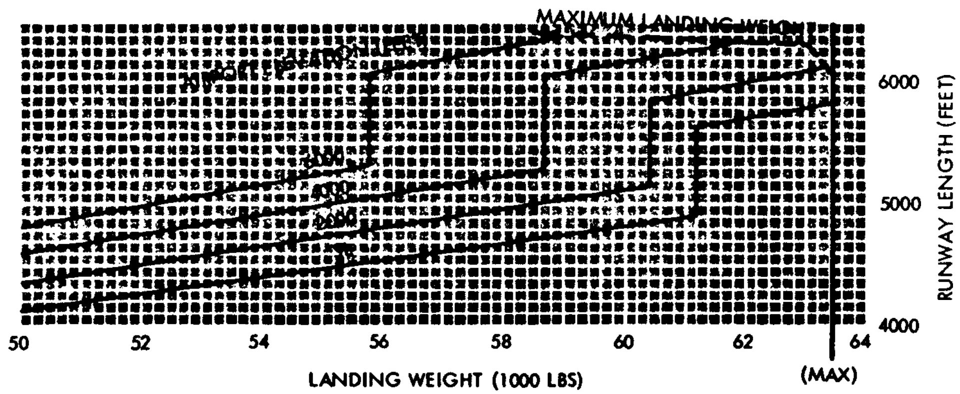


FIGURE 7. Aircraft Performance Curve, Landing (Douglas DC-4)

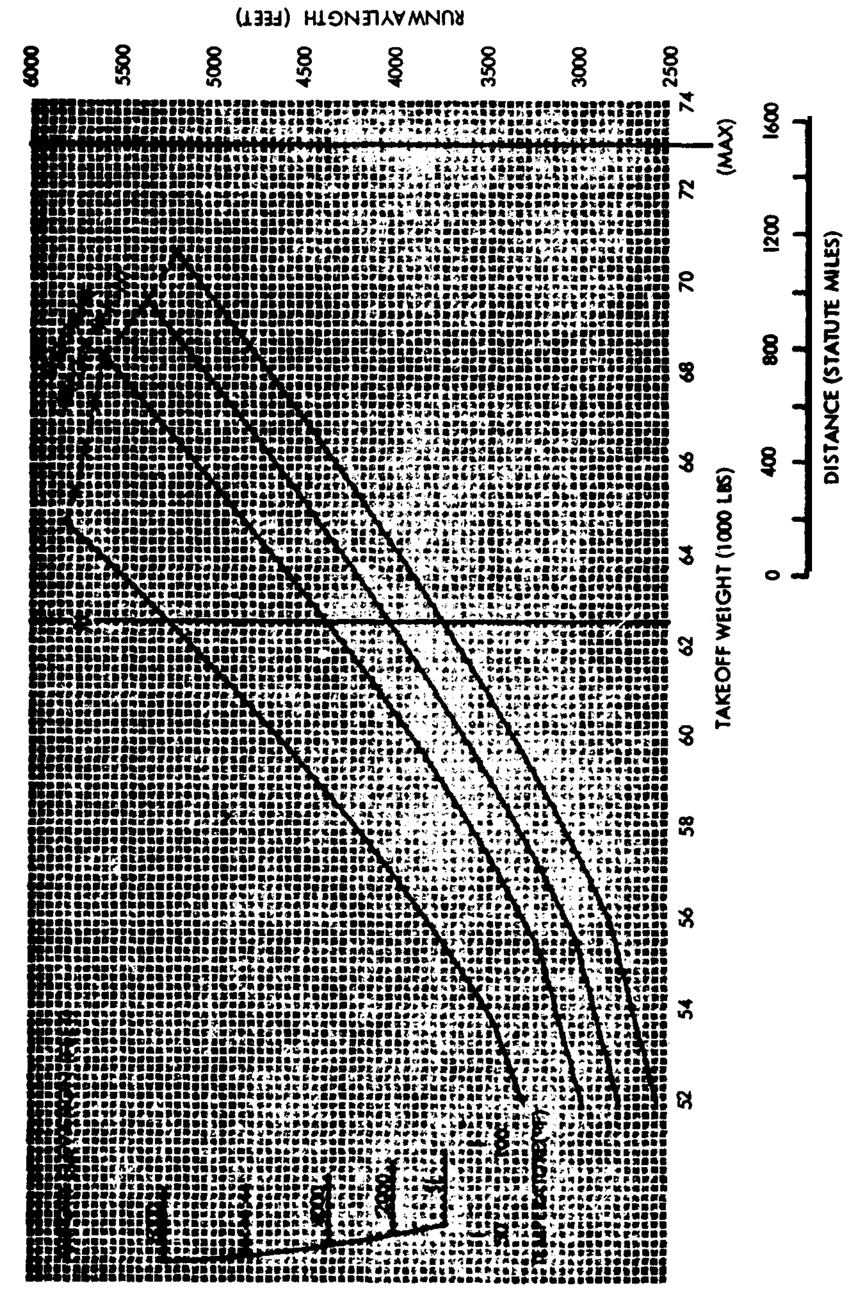
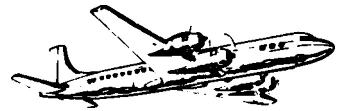


FIGURE 8. Aircraft Performance Curve, Takeoff (Douglas DC-4)



DOUGLAS DC-6A & 6B

PRATT & WHITNEY R2800-CB16 ENGINE

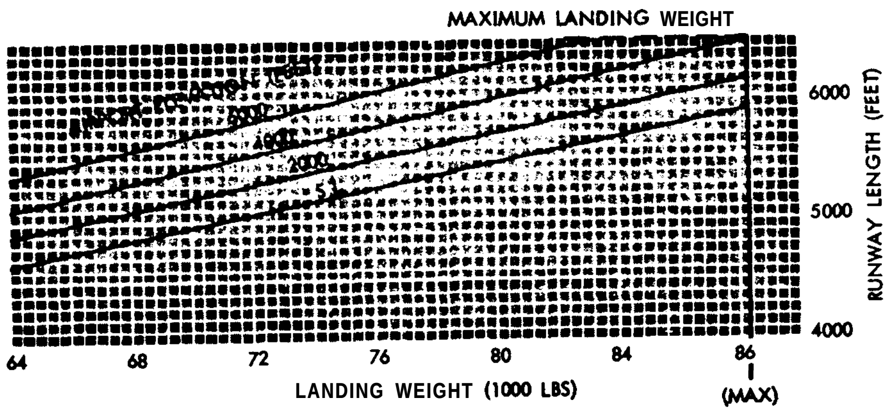


FIGURE 9. Aircraft Perfomsnce Curve, Landing (Douglas DC-6A & 6B)

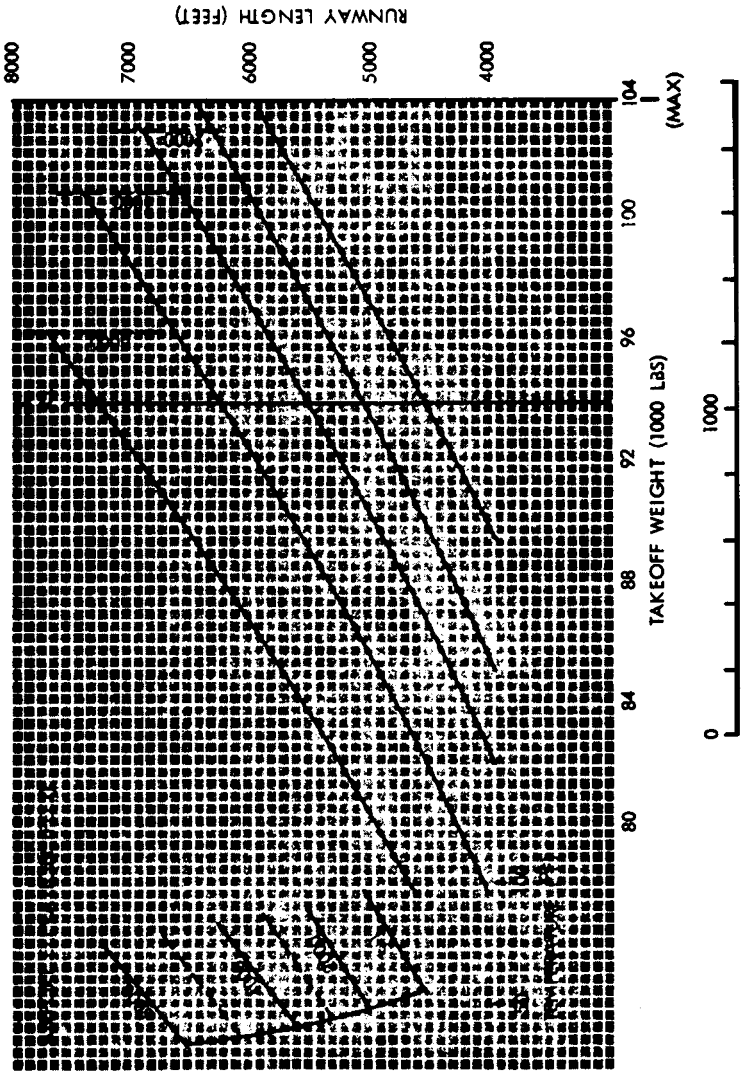


FIGURE 10. Aircraft Performance Curve, Takeoff (Douglas DC-6A & 6B)

DOUGLAS DC-7

WRIGHT 972 TC 18 DA2 ENGINE
972 TC 18 DA4

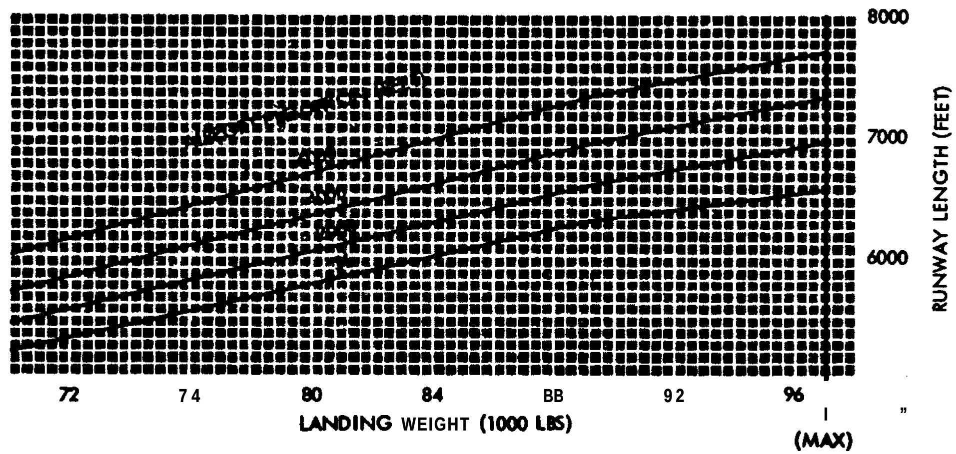


FIGURE 11. Aircraft Performnmce Curve, Landing (Douglas **DC-7)**

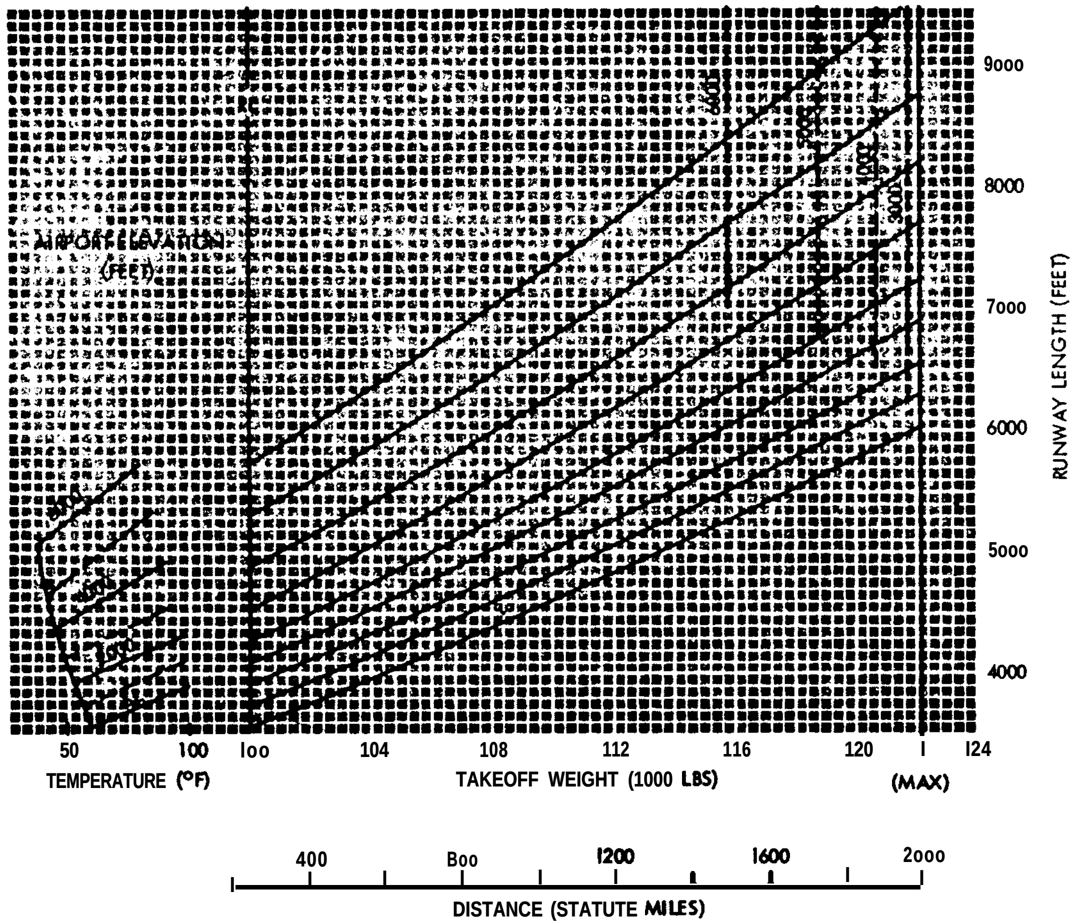


FIGURE 12. Aircraft Performance Curve, Takeoff (Douglas **DC-7)**