part 3
takeoff

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LIST OF ILLUSTRATIONS

INTRODUCTION.

The takeoff and climbout performance charts are presented in a form that allows corrections to be made for the several factors that affect performance. Some of the charts may be used only when the engine power is known. In these cases the brake horsepower, or BMEP, may be determined from the Brake Horsepower Available for Takeoff charts in Part 2. Generally, only 95 percent of the predicted power is used to determine takeoff performance.

On these charts where wind corrections are provided, the user shall apply 50 percent of the reported headwind and 150 percent of the reported tailwind except for the Takeoff Performance Ground Run, and Time Versus Speed charts. This is the recommended procedure, which may be revised at the discretion of the pilot, dependent upon the source of measurement of the wind data.

All the takeoff charts are based on a wing flap setting of 20 degrees. Each type of chart is discussed in detail below. Sample problems with chase-around lines are also provided on the individual charts to aid in their use.

Indicated takeoff speeds based on the pilot's and copilot's normal system, to be used for determining lift-off speed or to clear obstacles immediately after takeoff, are shown on the Ground Run chart (figure A3-4).

TAKEOFF TERMS — DEFINITION AND RELATIONSHIP.

THE TAKEOFF TERMS - Definition and Relationship chart (figure A3-1) illustrates the relationship of the terms used in the takeoff charts. Curve A shows the four-engine acceleration to takeoff speed and the distance traversed is the ground run. Curves B and D show that from the critical engine failure speed point the distance to accelerate on three engines to takeoff speed and the distance to stop are the same. This distance added to the distance required to reach critical engine failure speed is called the critical field length. Curve C shows that the refusal speed is the highest speed from which the takeoff may be aborted and the aircraft brought to a stop within the remaining runway length. The acceleration check point is a predetermined point, based on time or distance, at which the acceleration check speed or minimum acceptable speed must be attained. If runway length and critical field length were equal, curves C and D would coincide and the refusal speed would be the same as the critical engine failure speed. In this case the acceleration check speed will be lower than the critical engine failure speed.

RUNWAY CONDITION READING (RCR) - Stopping distance depends upon tire-to-runway coefficient of friction, which varies with condition of the runway surface. Runway surface condition will be reported as a Runway Condition Reading (RCR). The RCR is a measure of the coefficient of friction between the tire and the runway surface, as determined by an inspection decelerometer. All charts involving stopping distance are based on dry concrete or asphalt friction coefficients corresponding to an RCR of 23. Slippery runway surfaces will increase stopping distances; increased distances are accounted for by auxiliary grids as a function of RCR. RCR is reported as a whole number varying from 04 to 23. Many airfields will continue to report braking action in accordance with ICAO documents. This is the GOOD, MEDIUM, and POOR classification of braking action on unusual runway surface condition. To relate these classifications to an RCR, or when RCR values are not available, the following relationship will be used:

RUNWAY CONDITION	ICAO REPORT	RCR
Dry	Good	23
Wet	Medium	12
Icy	Poor	05

RUNWAY SURFACE COVERING (RSC) - Runway Surface Covering (RSC), which will be the average runway surface covering given in depth and type, such as slush, water, or snow, will also be reported. The depth of this covering can cause a significant reduction in takeoff performance due to the retarding effect of the tires displacing the covering, plus the additional drag effect of this material being sprayed and consequently striking the aircraft surfaces. The retarding effect of slush and water puddles increases as the speed increases. However, the retarding effect will vary considerably with varying slush and water depths encountered on the runway due to surface contour. The retarding effect of slush and water puddles will decrease when the aircraft reaches hydroplaning speed. Hydroplaning occurs because the pressure between the fluid on the runway and the tires increases until the tires are entirely supported on top of the fluid. The speed at which this occurs is called hydroplaning speed and is usually lower than end acceleration check speed. Due to the number of unpredictable conditions which affect acceleration with various types of runway covering, the acceleration check will not be an accurate indication of performance when takeoff is attempted in a measurable depth of slush, snow, or water.

CAUTION

As there are no corrections given for RSC, the pilot should exercise extreme caution during takeoff planning and ground run on water, slush, or snow covered runways.

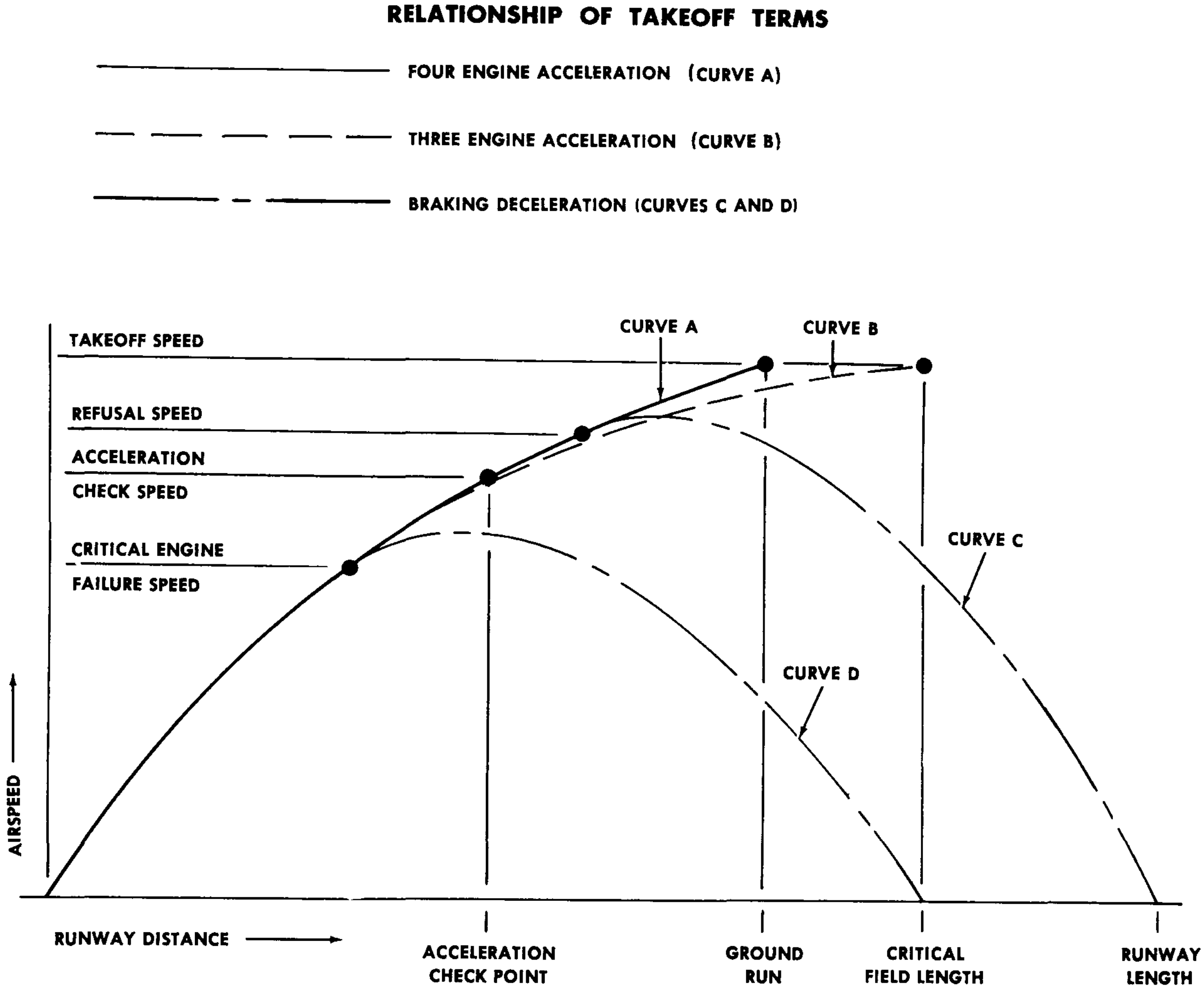


Figure A3-1. Takeoff Terms – Definition and Relationship

MAXIMUM TAKEOFF GROSS WEIGHT.

Safe operation of the aircraft requires that takeoffs not be attempted at gross weights for which acceleration, rate of climb, or obstacle clearance capability are marginal. There are four primary factors which must be considered when determining a safe limit for the takeoff gross weight.

1. The ability of the structure to withstand taxiing loads and inflight maneuvering loads is shown as design takeoff gross weights on the Gross Weight Limitation Chart in Section V.
2. The ability to take off or stop within the available runway is shown on the Critical Field Length charts (figures A3-6 and A3-7).
3. The ability to have adequate rate of climb when airborne is shown on the Gross Weight Limited by Three-Engine Climb Performance chart (figure A3-3).
4. The ability to clear obstacles within the takeoff corridor is determined by the Climbout Factor charts (figures A3-11 through A3-13) and the Gross Weight Limited By Climbout Over Obstacle chart (figure A3-14).

For a given set of takeoff conditions, each of these four considerations will permit a different gross weight. Any one of the four weights may be the lowest, depending on the conditions. For this reason, all four factors must be considered for each takeoff, even though in many cases one or more of them may be eliminated after cursory examination. The lowest weight determined by these factors will be the maximum takeoff gross weight.

TAKEOFF WITHOUT ALLOWANCE FOR ENGINE FAILURE.

Charts are provided to show the takeoff performance of the aircraft without allowance for engine failure. They are intended as a guide to show the ultimate performance should be determined by allowing for the possibility of an engine failure.

The takeoff of the airplane is made with a wing flap deflection of 20 degrees and with four engines operating at maximum power. Performance for this configuration is illustrated by the Takeoff Factor chart (figure A3-2), the Takeoff Performance – Ground Run chart (figure A3-4), the Effect of Runway Slope on Ground Run chart (figure A3-5), the Climbout Factor – Four-Engine – Ground Effect Not Included chart (figure A3-11) and the Gross Weight Limited By Climbout Over Obstacle chart (figure A3-14). An acceleration check may be determined from the Takeoff Performance – Distance and Time Vs Speed chart (figure A3-10). These charts are based on lifting off at the takeoff speed shown on the Takeoff Performance – Ground Run chart (figure A3-4) and maintaining that speed until the immediate obstacles are cleared.

TAKEOFF WITH ALLOWANCE FOR ENGINE FAILURE.

Normal takeoff planning procedure allows for the possibility of an engine failure during the takeoff. There are two methods for which data are provided herein.

CRITICAL FIELD LENGTH METHOD.

The critical field length method utilizes data from the Takeoff Performance – Critical Field Length charts (figures A3-6 and A3-7). When using this method, if an engine fails before the critical engine failure speed is reached, the aircraft is stopped. If an engine fails after the critical engine failure speed is reached, the takeoff is continued. Takeoff speeds are the same as those shown on the Takeoff Performance – Ground Run chart (figure A3-4). Climbout flight path data are determined from the Climbout Factor – Three-Engine charts (figures A3-12 and A3-13), and from the Gross Weight Limited By Climbout Over Obstacle chart (figure A3-14).

REFUSAL SPEED METHOD.

The refusal speed method will be used when the available runway is longer than the critical field length. This method utilizes data from the Takeoff Performance – Ground Run chart (figure A3-4), the Takeoff Performance – Refusal Speed charts (figures A3-8 and A3-9), and the Takeoff Performance – Distance and Time Versus Speed chart (figure A3-10). When using the method above, an acceleration check point (time and/or distance) and an acceleration speed will be determined to validate proper acceleration prior to reaching the refusal speed. If an engine fails, or the acceleration check speed is low at the designated acceleration check point, the aircraft is stopped. If an engine fails between the acceleration check point and refusal speed, the aircraft is also stopped. If an engine fails after reaching refusal speed, the takeoff should be continued.

However, it is possible for the aircraft performance to be better than predicted. This will generally be the case when 95 percent of the predicted BMEP is used to determine takeoff performance. The result can be acceleration to a higher speed than expected at the acceleration check point, from which the aircraft might not be stopped within the remaining length of runway. To avoid an attempt to stop from too high a speed, the takeoff should be continued if an engine fails after the aircraft has attained the acceleration check speed even though the acceleration check point has not been reached.

The following steps summarize what action should be taken when using the refusal speed method.

1. Stop (abort takeoff):
    a. If acceleration check speed is not attained by the time the acceleration check point, either time or distance, is reached.
    b. If engine failure occurs before acceleration check speed is attained.
    c. If an engine failure occurs between the acceleration check point and refusal speed.
2. Go (continue takeoff): If an engine failure occurs after reaching refusal speed.

If the acceleration check speed is less than the critical engine failure speed, it may not be possible to accelerate the aircraft to takeoff speed if an engine should fail shortly after attaining the acceleration check speed. In such cases the critical engine failure speed should be the abort criterion rather than the acceleration check point.

DISCUSSION OF CHARTS.

TAKEOFF PERFORMANCE – TAKEOFF FACTOR.

THE TAKEOFF PERFORMANCE – Takeoff Factor chart (figure A3-2) is used to provide a common factor for computing takeoff performance on the ground run, critical field length, and refusal speed charts, and for determining a climbout factor for the climbout flight path charts.

The chart uses BMEP versus Density altitude to provide a common factor for takeoff performance. BMEP values on this chart are based on operation in low blower at 2800 RPM. For takeoff in high blower and 2600 RPM use equivalent BMEP. Equivalent BMEP = high blower BMEP x 0.93. (See figure A2-6 and A2-7).

Sample Problem:

GIVEN: Density altitude = 7000 feet
BMEP = 160 PSI

FIND: Takeoff factor.

1. Enter chart at density altitude of 7000 feet (A) and read across to 160 BMEP (B).

2. Read down to find takeoff factor of 14 (C).

GROSS WEIGHT LIMITED BY THREE-ENGINE CLIMB PERFORMANCE CHART.

The effect of pressure altitude and engine power on climb performance cannot be shown accurately as limit lines on the critical field length charts. For this reason, the Takeoff Gross Weight Limited By Three-Engine Climb Performance chart (figure A3-3) is provided to indicate the gross weight limit required to achieve the desired rate of climb. Curves are provided to indicate the gross weight for zero, 50, 100, and 200 feet per minute rate of climb at lift-off with gear down and inoperative propeller windmilling, and for 50, 100, 200 and 300 feet per minute rate of climb with the gear up and the inoperative propeller feathered. The rate of climb in each case is based on climb at takeoff speed with the wing flaps set for takeoff and no ground effect.

NOTE

The operating command should establish their rate of climb limitations depending on operational requirements. Aircraft gross weight at takeoff should permit at least 50 feet per minute rate of climb with the gear retracted.

The design takeoff gross weights of 107,000 pounds for normal operation and 112,000 pounds for war emergency are also indicated on the chart. These limits should not be exceeded even though the rate of climb may be adequate.

The use of this chart requires that the BMEP and Takeoff Factor be known. The BMEP may be obtained from the Brake Horsepower Available for Takeoff chart in Part 2. Generally, 95 percent of the predicted BMEP is used to enter this chart. For takeoff in high blower use equivalent BMEP. Use density altitude from the Density Altitude Chart, (figure A1-9), in finding the takeoff factor.

Sample Problem:

GIVEN: Takeoff Factor = 7.
BMEP = 210 psi.

FIND: Gross weight for zero rate of climb at liftoff with gear down and inoperative propeller windmilling and for 50 feet per minute rate of climb with gear up and inoperative propeller feathered.

1. Enter the chart with Takeoff Factor of 7 (A).

2. Read up to BMEP of 210 (B) and across to the zero rate of climb for lift-off (C).

3. Read down to find gross weight of 100,200 pounds (D).

4. Continue across the chart to the 50 foot per minute rate of climb line for gear up and note intersection would be off the chart so the maximum gross weight at which 50 feet per minute rate of climb could be maintained is greater than 112,000 pounds.

GROUND RUN CHART.

The ground run chart (figure A3-4) shows the distance required to accelerate from a standstill to takeoff speed on a dry, hard-surface, level runway with all four engines operating. Indicated takeoff speeds are shown for the pilot's and copilot's normal system. The takeoff factor needed for the use of this chart may be obtained from the Takeoff Performance - Takeoff Factor chart (figure A3-2).

Sample Problem:

GIVEN: Takeoff factor = 8.5.
Gross weight = 95,000 pounds.
Wind = 20 knots headwind (100 percent of reported headwind).

FIND: Takeoff ground run corrected for wind.

1. Enter the chart with takeoff factor of 8.5 (A) and read across to gross weight of 95,000 pounds (B).

2. Read down to find uncorrected ground run of 4600 feet (C).

3. Correct for wind by following headwind curve to 20 knots (D) and reading down to find corrected ground run of 3400 feet (E).

RUNWAY SLOPE CORRECTION CHART.

This chart (figure A3-5) is to be used to correct data obtained from the Ground Run chart (figure A3-4) when runways have slopes other than zero. Where runway slope is reported in percentage, multiply chart values by 100 to obtain percentage.

CRITICAL FIELD LENGTH CHART.

The critical field length as shown in figures A3-6 and A3-7 is defined as the distance required to accelerate with four engines from a standstill to the critical engine failure speed, experience an engine failure, and then either come to a stop or continue accelerating with three engines to the takeoff speed in the same distance. Critical engine failure speed is determined by entering the Refusal Speed chart, using critical field length for runway length, and computing speed in the same manner as for refusal speed.

The stopping distance has been determined by the use of brakes only, and by the use of brakes plus two engines reverse thrust. Since, in most cases, reverse thrust may be used, it should not be difficult to duplicate this stopping distance even though runway conditions may not be so favorable. As an added safety margin, these data are based on a 3-second time delay after reaching the critical engine failure speed before the engines are cut and the brakes applied.

The three-engine acceleration part of the critical field length is based on the inoperative propeller windmilling. The indicated takeoff speeds may be obtained from the Ground Run chart (figure A3-4). The following sample problem illustrates the method of using the critical field length charts.

GIVEN: Takeoff factor = 9.0.
Gross weight = 95,000 pounds.
Wind = 20 knots headwind (50% of reported headwind).
RCR = 15.
Brakes only.

FIND: Critical field length corrected for wind and RCR.

1. Enter chart (figure A3-6) at takeoff factor of 9.0 (A), read across to gross weight of 95,000 pounds (B).

2. Read down to zero wind line for uncorrected critical field length of 6050 feet (C), follow guide line to the 20 knot headwind line (D) read straight down for critical field length corrected for wind of 4900 feet (E).

3. Follow guide lines to RCR factor of 15 (F) and read down to obtain critical field length of 4970 feet corrected for wind and RCR (G).

REFUSAL SPEED CHART.

The usual situation during operation of the C-118A aircraft is to have an actual runway length greater than the critical field length for the given conditions. Since it is always desirable to safely stop an aircraft within the limits of the runway in the event of an engine failure rather than risk a three-engine takeoff and go-around, the refusal speed charts (figures A3-8 and A3-9) are presented to allow the decision to stop to be made at the highest speed possible.

The refusal speed as shown on these charts is defined as the maximum speed which may be reached, accelerating from a standstill with four engines operating, and from which a stop may be made within a given runway length. If the critical field length and runway length are the same, then refusal speed and critical engine failure speed are identical. If, however, the runway length is greater than critical field length, then the refusal speed may be considerably higher than the critical engine failure speed. For this reason, the refusal speed is of primary importance during takeoff operation. It must be remembered that the validity of refusal speed is dependent upon a normal four-engine acceleration of the aircraft. If the acceleration is low, the aircraft will have used more runway than predicted in reaching the refusal speed, and insufficient runway will remain in which to stop the aircraft. For this reason, use of acceleration check speeds or times is necessary to ensure safe takeoff.

The refusal speed charts show correction for runway slope, wind, and RCR. Whenever the takeoff speed, after correction for crosswind component (as necessary) is less than refusal speed, takeoff speed should be used for refusal speed.

A sample problem illustrating the use of the refusal speed charts is included on the chart for brakes only (figure A3-8).

TIME VS SPEED CHART.

The acceleration-time relationship of normal takeoff may be obtained from figure A3-10. To use this chart it is necessary to know the indicated airspeed at lift-off and takeoff distance corrected for wind and slope. By entering the chart with these two values, an acceleration curve guideline is established which represents the acceleration of the aircraft during the take-off run. The acceleration time check provides the most accurate means of checking acceleration. With this method, an even 10 knot increment not less than 5 and not more than 15 knots below refusal speed will be used as an acceleration check speed.

Sample Problem (Headwind):

GIVEN: Wind = 10 knots headwind (100 percent of reported headwind).

Ground run (corrected for headwind and slope) = 3000 feet.

Takeoff speed = 109 KIAS.

Refusal speed (corrected for headwind and slope) = 100 KIAS.

Density altitude = 2000 feet.

FIND: Acceleration check speed.

1. Subtract headwind from takeoff speed to obtain corrected takeoff speed (109 - 10 = 99 KIAS). Enter chart with corrected takeoff speed of 99 KIAS (A) and read up to ground run (corrected for headwind) of 3000 feet (B) and establish a contour line by following the guide lines.

2. Determine check speed from refusal speed (100 - 10 = 90 KIAS).

3. Follow down the guideline established in step 1 until intercepting the vertical line from 80 knots (90 KIAS - 10 knots head-

wind). At this point determine the acceleration time of 24 seconds. Then from the ICAO Standard Atmosphere Table (figure A1-10) determine $1/\sqrt{\sigma}$ for 2000 feet of density altitude of 1.0299. Correct acceleration time by dividing this figure. Actual time will be 24.0 ÷ 1.0299 = 23.3 seconds.

4. Correct acceleration check speed by adding headwind velocity (80 + 10 = 90 KIAS). Therefore, the aircraft should accelerate to 90 KIAS within 23.3 seconds.

CLIMBOUT FACTOR CHARTS.

The Climbout Factor charts (figures A3-11 through A3-13) are used to compute climbout data in conjunction with the Gross Weight Limited By Climbout Over Obstacle chart (figure A3-14). Charts are provided for four-engine operation without ground effect and for three-engine operation with and without ground effect. The charts are plotted so that at zero height, the climbout factor given conditions will represent four-engine ground run (uncorrected for slope) on the four-engine charts, and critical field length on the three-engine charts, for the same given conditions.

The two methods of using the charts are illustrated on figure A3-12. Sheet 1 shows method of determining a climbout factor which is then used to determine the maximum gross weight allowable for clearance of an obstacle, on the Gross Weight Limited By Climbout Over Obstacle chart (figure A3-14). Sheet 2 illustrates the method of determining the height over a given point using a climbout factor determined from figure A3-14, based on a given gross weight and takeoff factor.

Climbout and Ground Effect.

Ground effect, in general, refers to a reduction in the overall drag of an aircraft when operated in close proximity to the ground. The degree of drag reduction will vary with distance of the wing from the ground, being greatest when the wing is at ground level. Ground effect will, for all practical purposes, disappear when the wing is greater than one half the wing span above the ground. Ground effect is greatest at low airspeeds and becomes a lesser drag reduction as airspeed increases.

Climbout data is provided for three-engine operation both with and without ground effect. Four-Engine operation is based on no ground effect since the normal climbout flight path is steep enough that the aircraft will climb above the altitude where ground effect is noticeable shortly after lift-off.

For three-engine operation, on a takeoff over level terrain or with only a slight downhill slope the flight path will be such that the aircraft performance will be influenced by ground effect for a longer period of time, which will result in a more rapid acceleration to climb speed than would be possible where takeoff is over terrain which slopes sharply downhill after the point of life-off.

1. Ground Effect Included chart – Use this chart when the terrain does not slope downhill more than 5 percent from point of lift-off to the point where aircraft will have reached an altitude equal to one half the wing span.

2. Ground Effect Not Included chart – Use this chart when the applicable slope is greater than 15 percent.

3. Both Charts – If the applicable slope is between 5 and 15 percent, assume a climbout factor half way between the two charts.

GROSS WEIGHT LIMITED BY CLIMBOUT OVER OBSTACLE CHART.

The Gross Weight Limited By Climbout Over-Obstacle chart (figure A3-14) is used to compute climbout data in conjunction with the Climbout Factor charts (figure A3-11 through A3-13), and the Takeoff Factor chart (figure A3-2). The chart may be used to determine the maximum allowable gross weight for clearance of an obstacle, using a takeoff factor and climbout factor obtained from the appropriate charts, or to determine a climbout factor for a given gross weight, which is then used to compute the altitude which may be expected over an obstacle; obstacle clearance speed is the same as takeoff speed.

The critical field length portion of the total distance shown is for a dry, level runway. However, for other than dry runway conditions or with an uphill slope, critical field length is extended resulting in a reduced in-flight distance to the obstacle. For this case, it is necessary, before entering the chart, to decrease the known distance from brake release by the difference between actual critical field length (corrected for existing RCR and slope) and the critical field length for dry level runway. In determining the corrected critical field length, do not apply a correction for headwind. Refer to application of winds to takeoff and landing text.

Sample Problem (1):

GIVEN: Climbout factor = 10.8.
Takeoff factor = 3.0.

FIND: Maximum gross weight for climbout over an obstacle.

1. Enter chart with climbout factor of 10.8 (A) and takeoff factor of 3.0 (B), obtained from figures A3-12 and A3-2.

2. At the intersection of climbout and takeoff factor lines read maximum allowable gross weight of 102,250 pounds (C).

Sample Problem (2):

The following sample problem illustrates the method for obtaining the climbout factor using RCR and runway slope correction.

GIVEN: Gross weight = 100,000 pounds.
Takeoff factor = -0.1.
RCR = 5.
Runway slope = 0.02 (uphill).
Obstacle height = 150 feet.
Obstacle distance = 10,000 feet.

FIND: Climbout factor for use in determining altitude over the obstacle.

1. Enter Gross Weight Limited By Climbout Over Obstacle chart (figure A3-14) with takeoff factor of -0.1.

2. Read across to a gross weight of 100,000 pounds and down to find a climbout factor of 10.

3. Enter the Takeoff Performance – Critical Field Length – Brakes Only chart (figure A3-6) with the takeoff factor of -0.1, read across to gross weight of 100,000 pounds, and read down to obtain a critical field length distance of 4300 feet uncorrected. Follow the guide line down to RCR of 5 to obtain a critical field length corrected for RCR of 4400 feet.

4. Enter Takeoff Performance – Runway Slope Correction chart (figure A3-5) with a critical field length distance, corrected for RCR, of 4400 feet, read up to runway slope (uphill) 0.02, and read across to obtain a critical field length corrected for runway slope of 5130 feet.

5. Subtract critical field length of 4300 feet from the critical field length corrected for RCR and runway slope of 5130 feet to obtain a correction of 830 feet. The obstacle distance corrected for RCR and runway slope is 10,000 feet -830 feet = 9170 feet.

6. Enter Climbout Factor - Three-Engine - Ground Effect Not Included chart (figure A3-12) with corrected obstacle distance of 9170 feet, read up to climbout factor of 10, and read to the left to obtain altitude at the obstacle of 165 feet which is 15 feet above the obstacle.

TAKEOFF DISTANCE TO 50-FT HEIGHT, THREE-ENGINE FERRY CONFIGURATION CHART.

The three-engine ferry takeoff performance (figure A3-15) is based on starting the ground roll with maximum power on only the two asymmetrical engines. The odd engine begins with idle power and increases to maximum power as rapidly as the rudder effectiveness permits control of the asymmetrical power. The takeoff speeds noted on the chart are 130 percent of the stalling speeds instead of the usual 115 percent for normal takeoffs. Takeoff speed and climb speed to 50-foot height are the same. The inoperative propeller is considered either feathered or removed, and there is no allowance for engine failure during the takeoff. The ground run is approximately 87 percent of the takeoff distance to a 50-foot height.

DISTANCE TO STOP CHARTS.

The distance To Stop charts (figures A3-16 and A3-17) are provided for stopping with brakes only and with brakes plus two-engine reverse thrust. The charts show the distance required to stop from a given indicated airspeed for various runway surface conditions and density altitudes. Both charts are based on wing flaps in the takeoff configuration.

Sample Problem:

GIVEN: Airspeed at which brakes are applied = 85.0 knots.
Runway condition = Dry.
Density altitude = Sea level.

FIND: Required stopping distance with brakes only.

1. Enter the brakes only chart (figure A3-16) at an airspeed of 85.0 knots (A) and read across to RCR of 23 (B).

2. Read up to density altitude of sea level (C) and across to find the required stopping distance of 2500 feet (D).

APPLICATION OF WINDS.

DEFINITIONS

Steady Wind Value	Reported steady wind.
Gust Increment	Reported wind in excess of Steady Wind Value.
Component	Effective wind parallel or across the runway.
Headwind	Effective wind parallel to the runway, determined from the Steady Wind Value.
Tailwind	Effective wind parallel to the runway, determined from the Steady Wind Value plus the Gust Increment.
Crosswind	Effective wind across the runway, determined from the Steady Wind Value plus the Gust Increment.

WIND SUMMARY

Type of Wind	How to Obtain Component	Use of Wind Component
HEADWIND	Runway Component	Apply 100 percent of component to Takeoff Performance Ground Run, and Time versus Speed Charts.
	Enter wind component chart with steady wind value.	Apply 50 percent of component to Critical Field Length, Refusal Speed, and Landing Ground Roll charts.
		Do not apply headwinds for terrain clearance.
TAILWIND	Runway Component	Apply 100 percent of component to Takeoff Performance Ground Run, and Time versus Speed Charts.
	Enter wind component chart with steady wind value plus the gust increment.	Apply 150 percent of component to Critical Field Length, Refusal Speed, and Landing Ground Roll charts.
		Apply 150 percent of component for terrain clearance.
CROSSWIND	Crosswind Component	Adjust ground minimum control speed for 100 percent of component.
	Enter wind component chart with steady wind value plus the gust increment.	Check necessity of increased takeoff and landing speeds.
GUSTS	Gust Increment	Increase takeoff speed, final approach speed, and landing speed by the full gust increment not to exceed 10 knots.
	Reported wind in excess of steady wind value.	

APPLICATION OF WINDS TO TAKEOFF AND LANDING.

Wind Direction and Velocity.

Winds are usually measured at some fixed point on the airfield, and within instrument limitations are valid for the point where measured. However, if the airfield is located in an area of variable terrain, the possibility exists that over various portions of the airfield, wind velocity and direction will vary. Likewise, wind shear can result in varying winds during climbout and landings.

Because of these variables, it is recommended that 50 percent of the headwind component and 150 percent of the tailwind component be applied (except Takeoff Performance Ground Run, and Time versus Speed Charts) per attached chart. Gusts may cause a temporary increase in airspeed; therefore, takeoff speed, final approach speed, threshold speed and landing speed should be increased by the full gust increment, but not to exceed 10 knots. Terrain clearance distances should only be adjusted for gusts on correction grids when they accompany a tailwind.

Accounting for Wind.

Benefits derived from headwinds should be accepted as an increased margin of safety. Headwind should only be considered when necessary for mission accomplishment. When using this concept, headwind will be used when computing takeoff performance ground run and time versus speed. Always apply tailwinds. When headwinds or tailwinds are applied, all distances and speeds except takeoff speed and ground minimum control speed must be corrected during takeoff planning.

TAKEOFF AND LANDING CROSSWIND CHART.

The Takeoff and Landing Crosswind chart (figure A3-18) presents headwind (or tailwind) and crosswind components in knots for crosswind angles of 0 to 90 degrees for wind speeds up to 60 knots. The minimum nosewheel lift-off or touchdown speed is also presented. The maximum crosswind component for either takeoff or landing is 30 knots, and the maximum wind in any direction is 50 knots.

With the aid of the chart, wind from any direction may be separated into a headwind or tailwind component and a crosswind component. If the crosswind component falls to the right of the minimum speed reference line, determine the minimum nosewheel lift-off or touchdown speed as demonstrated in the sample problem. The chart is entered with maximum gust velocity to determine crosswind and tailwind components, and with maximum steady wind to determine headwind components.

Use either the gust correction or increased lift-off or touchdown speed due to crosswind, whichever is greater, but in no case should the correction be greater than 10 knots.

Whenever lift-off or touchdown speed is increased for either crosswind or gust correction, the pilot must be prepared to accept a correspondingly longer ground roll. For takeoff, the ground run is corrected on the Distance and Time Versus Speed chart (figure A3-10) for the increased speed. Refusal speed, distance, and time, however, will remain the same. For landing, increased touchdown speed may dictate the selection of an alternate flap setting with a proportionate increase in approach and touchdown speed. Select the flap setting that will give a speed compatible with the minimum touchdown speed after correction for crosswind or gust, and compute landing ground roll for this flap setting.

To compute headwind, tailwind, and crosswind components, a wind angle relative to the takeoff or landing runway must first be determined from the existing surface wind conditions as follows:

1. Subtract the runway heading angle from the magnetic wind direction.
2. If the resultant angle is between 90 and 180 degrees (regardless of sign, + or -), it should be subtracted from 180 degrees to obtain the crosswind angle. If the resultant angle is between 180 and 270 degrees, it should be subtracted from 270 degrees. If the resultant angle is between 270 and 360 degrees, it should be subtracted from 360 degrees.
3. The Takeoff and Landing Crosswind chart may then be entered to obtain the headwind, tailwind, and crosswind components.

Sample Problem:

GIVEN: Runway heading = 030 (30 degrees).
Wind direction = 85 degrees.
Steady wind velocity = 25 knots.
Gust velocity = 36 knots.

FIND: Headwind component, crosswind component, and minimum nosewheel lift-off speed.

1. Determine wind angle = 85 - 30 = 55 degrees.
2. Enter chart with wind angle of 55 degrees (A) and read to maximum gust velocity arc of 36 knots (B).
3. Read down to find crosswind component of 29.5 knots (C).
4. Since crosswind component is to the right of the minimum speed reference line, determine minimum nosewheel lift-off and touchdown speed by reading up to the reference line (D), and across to find minimum speed of 120.5 knots (E).
5. Determine headwind component by following wind angle line to steady wind velocity of 25 knots (F), and reading to the left for a headwind component of 14.5 knots (G). (In the event that wind angle results in a tailwind condition, the tailwind component is determined by reading to the left from maximum gust velocity at point B.)

MINIMUM CONTROL SPEED VS BANK ANGLE.

The Minimum Control Speed Vs Bank Angle chart (figure A3-19) is provided to show the effect of bank angle on minimum control speed. Minimum control speed is the slowest speed at which directional control may be maintained under conditions of asymetrical thrust. Assuming full rudder deflection, additional directional control may be obtained by banking away from the inoperative engine. The chart is based on one outboard engine inoperative with the propeller windmilling and the remaining engines operating at 2500 BHP. The minimum control speed will be lower with an inboard engine inoperative, with the propeller on the inoperative engine feathered, or with the engines operating at a lower BHP. The chart shows the decrease in minimum control speed as the aircraft is banked away from the inoperative engine. If the bank angle is toward the inoperative engine, the minimum control speed will increase at approximately the same rate as it decreases when banking in the opposite direction. The relationship between minimum control speed and bank angle as shown on the chart illustrates the importance of initiating a bank away from the inoperative engine as soon as possible after engine failure.

NOTE

The Minimum Control Speed Vs Bank Angle chart reflects 100 percent of minimum control speed. For asymmetric power conditions, 110 percent of minimum control speed or 115 percent of stall speed (whichever is greater) shall be used.

TAKEOFF PERFORMANCE – TAKEOFF FACTOR

2800 RPM

MODEL: C-118A
DATA AS OF: 10-15-64
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W

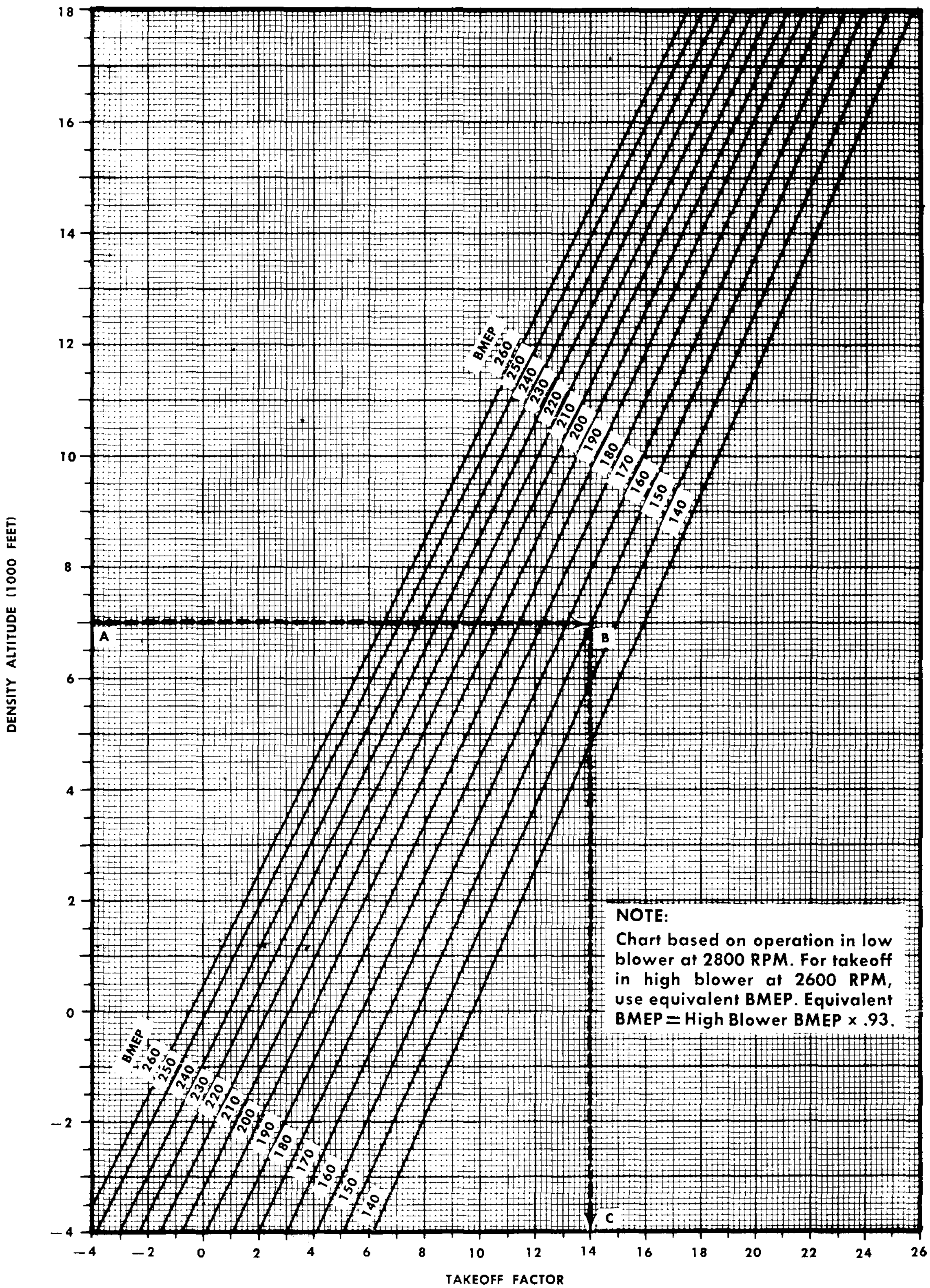


Figure A3-2. Takeoff Performance - Takeoff Factor

TAKEOFF GROSS WEIGHT LIMITED BY THREE-ENGINE CLIMB PERFORMANCE

WING FLAPS 20 DEGREES – CLIMB AT TAKEOFF SPEED
NO GROUND EFFECT

MODEL: C-118A
DATE: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W

NOTE:
The structural limit of 107,000 pounds must not be exceeded for normal operation nor 112,000 pounds for emergency.

LEGEND:
——— Gear up, inoperative propeller feathered.
— — — Gear down, inoperative propeller windmilling.

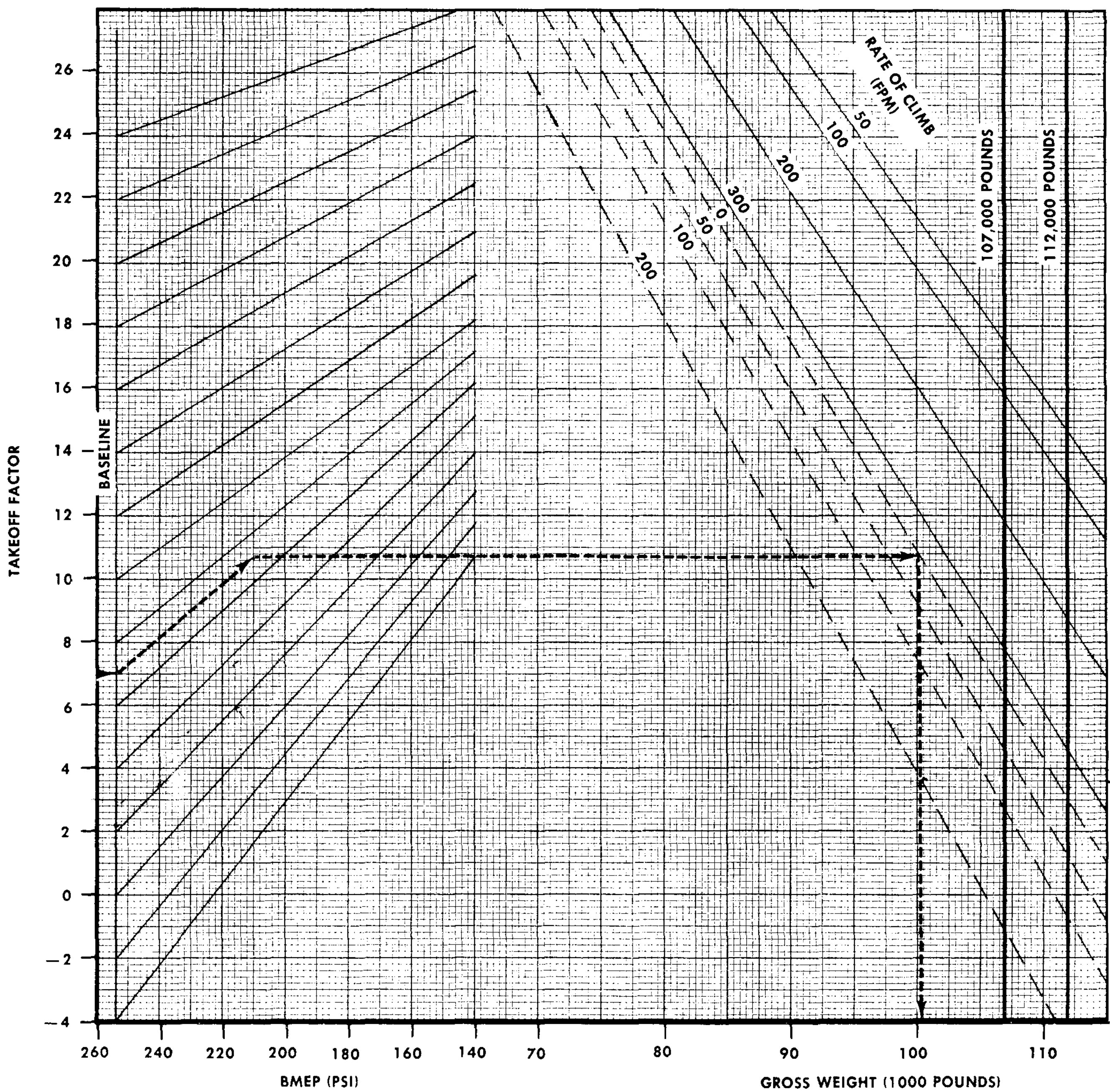


Figure A3-3. Takeoff Gross Weight Limited by Three-Engine Climb Performance.

TAKEOFF PERFORMANCE – GROUND RUN

ALL ENGINES OPERATING 2800 RPM
WING FLAPS 20 DEGREES

MODEL: C-118A
DATA AS OF: 10-20-72
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W

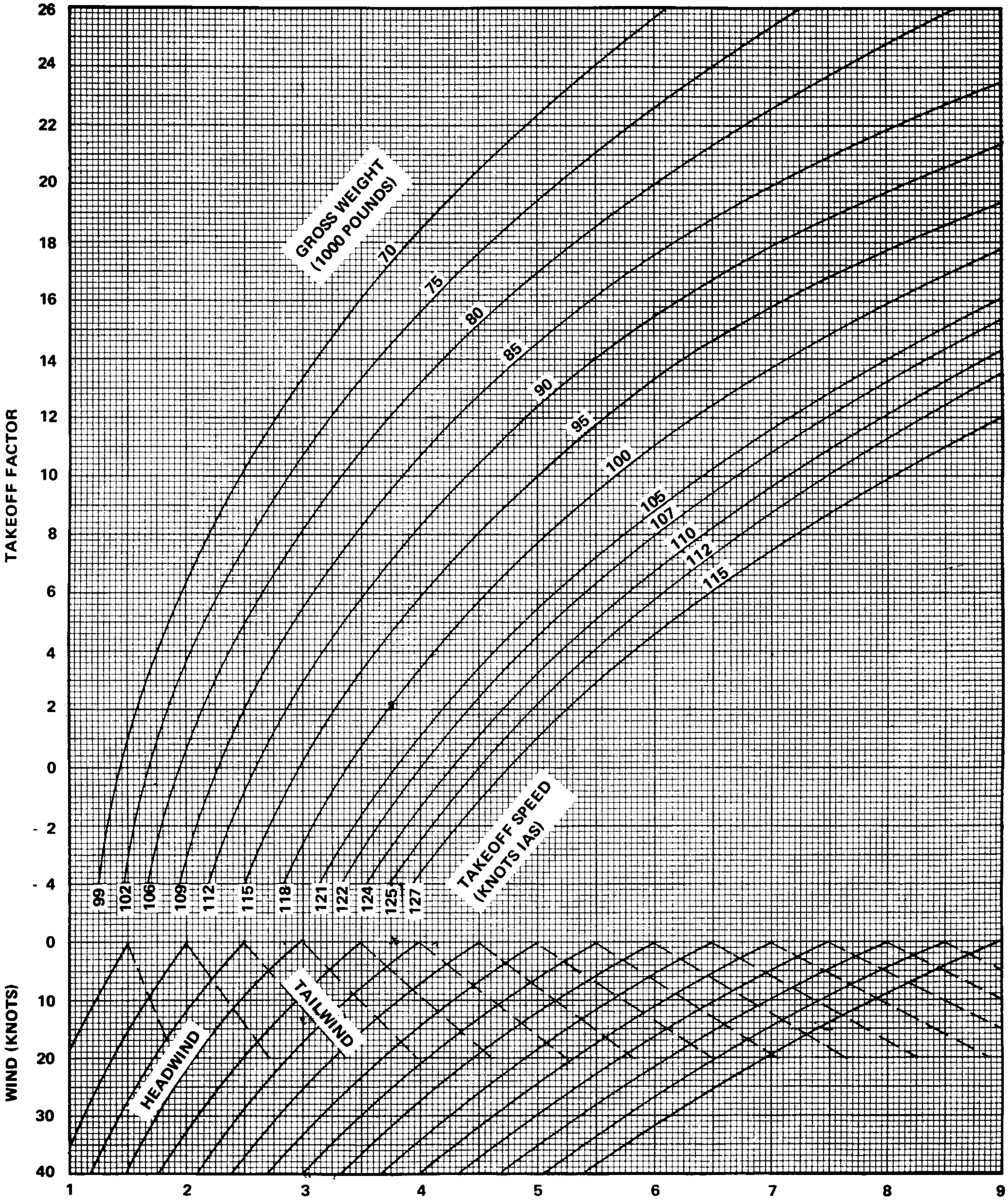


Figure A3-4. Takeoff Performance - Ground Run

TAKEOFF PERFORMANCE – RUNWAY SLOPE CORRECTION

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
This chart applicable to:
4 engine ground run,
Critical field length, brakes only.
Critical field length, and brakes plus two engine reverse.

SAMPLE PROBLEM:
A. Distance without runway slope = 4600 feet.
B. Runway slope = .035.
C. Distance with runway slope = 6200 feet.

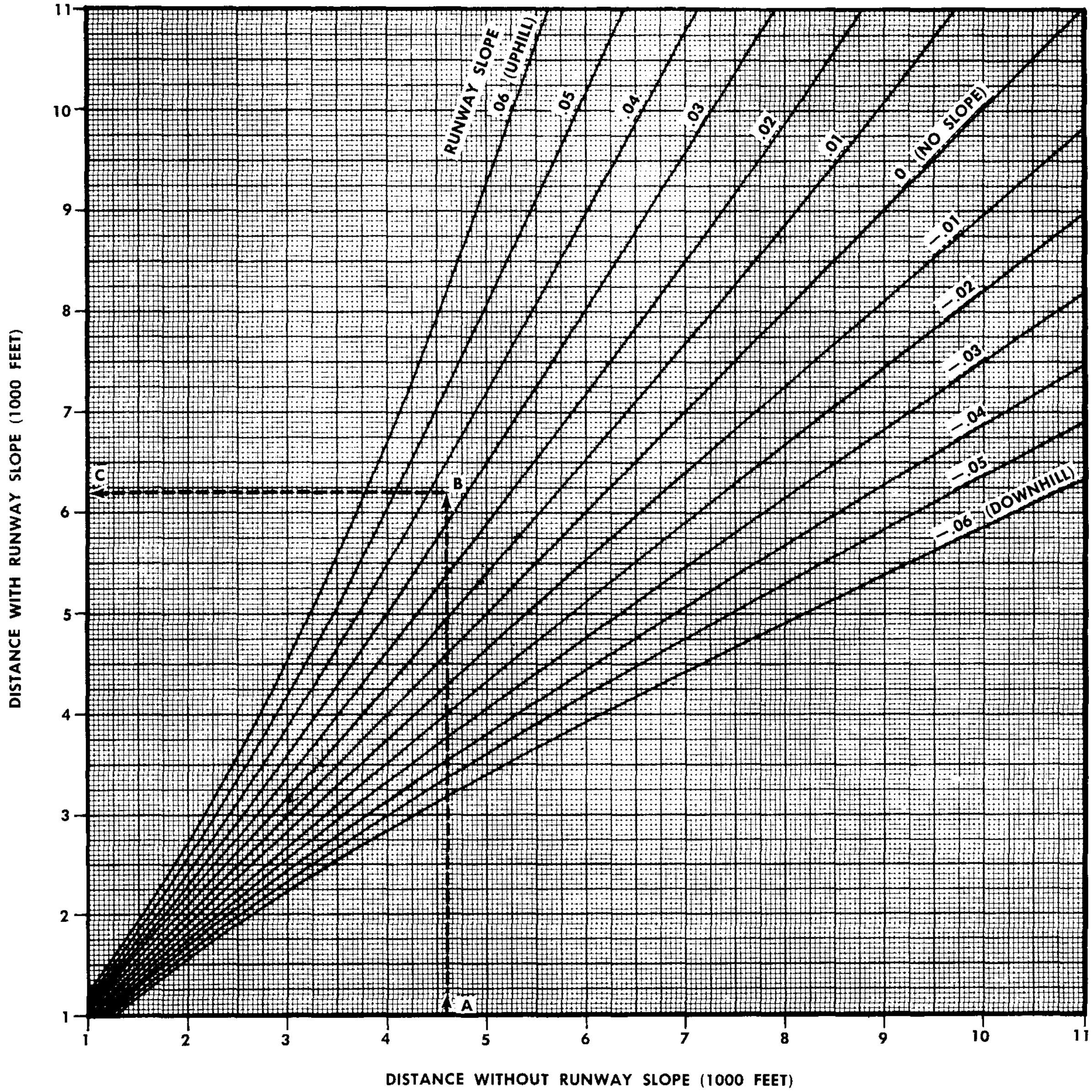


Figure A3-5. Takeoff Performance - Runway Slope Correction

TAKEOFF PERFORMANCE – CRITICAL FIELD LENGTH – BRAKES ONLY

2800 RPM

WING FLAPS 20 DEGREES

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W

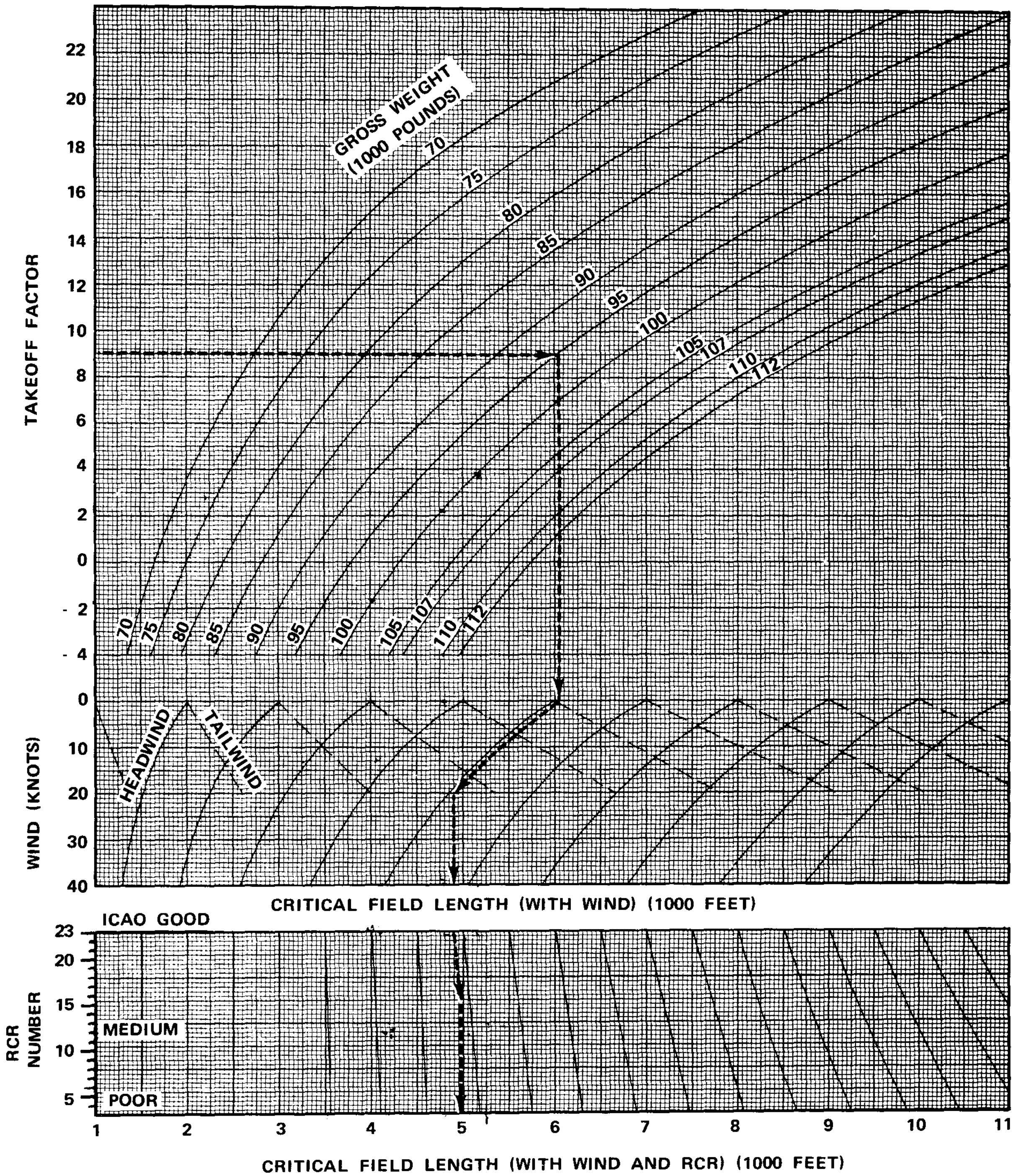


Figure A3-6. Takeoff Performance - Critical Field Length - Brakes Only

TAKEOFF PERFORMANCE – CRITICAL FIELD LENGTH – BRAKES PLUS TWO-ENGINE REVERSE THRUST

2800 RPM

WING FLAPS 20 DEGREES

MODEL: C-118A

DATA AS OF: NOV 1972

DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W

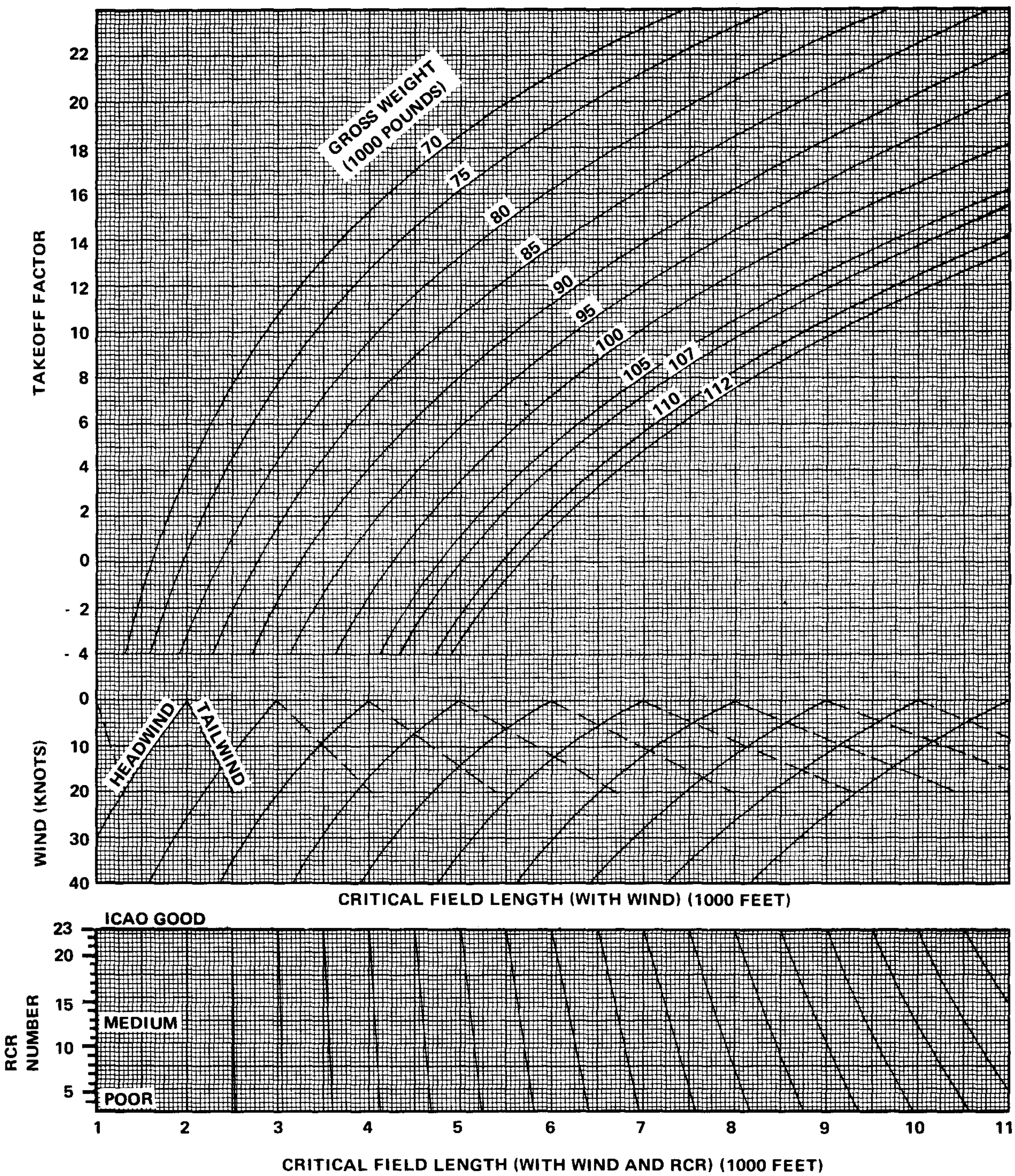


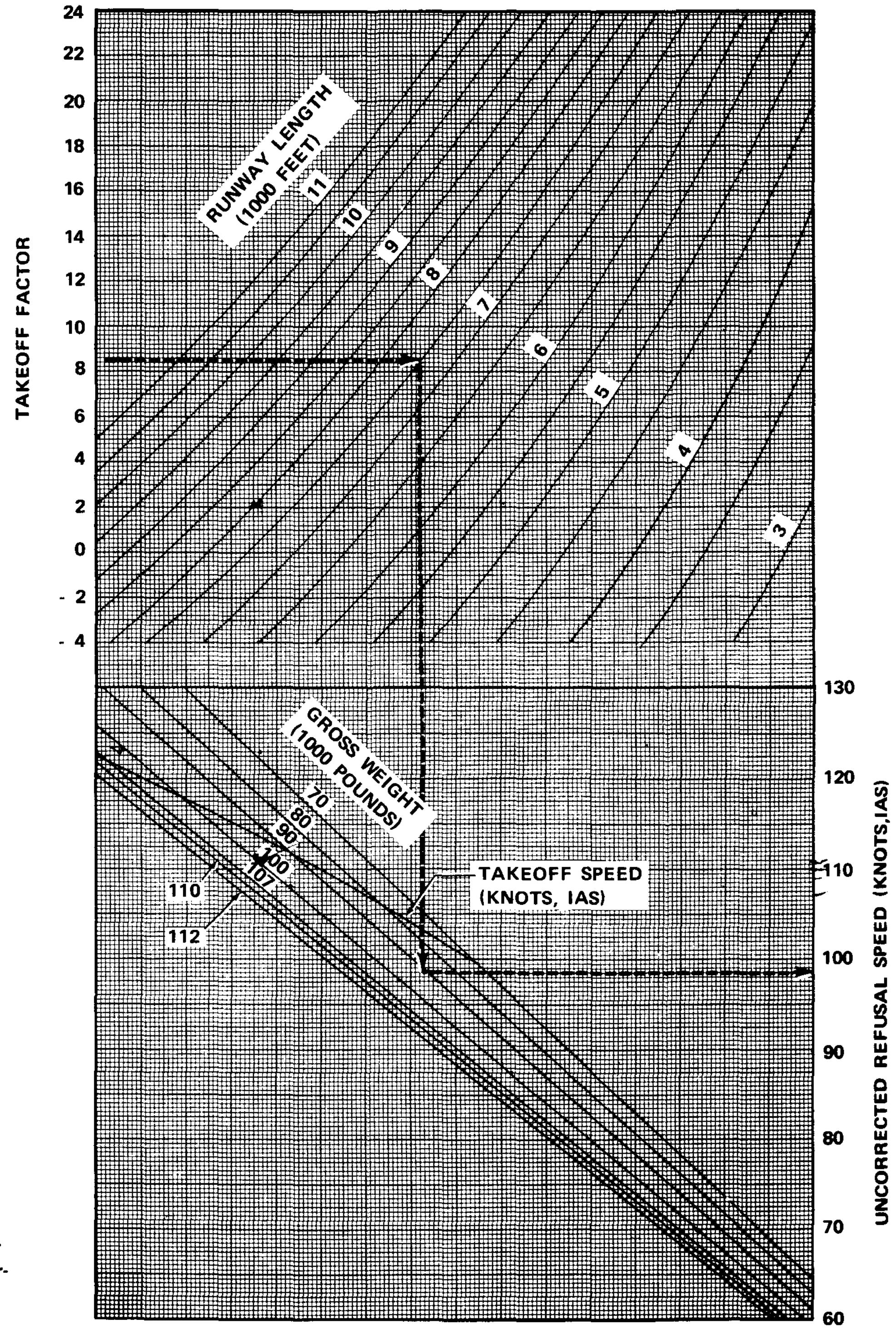
Figure A3-7. Takeoff Performance - Critcal Field Length - Brakes Plus Two-Engine Reverse Thrust

TAKEOFF PERFORMANCE – REFUSAL SPEED – BRAKES ONLY

2800 RPM
WING FLAPS 20 DEGREES

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES (4) R2800-52W



SAMPLE PROBLEM:

A. Takeoff factor = 8.5.
B. Runway length = 7500 feet.
C. Gross weight = 92,000 pounds.
D. Uncorrected refusal speed = 98.5 knots.
E. Takeoff speed line.
F. Takeoff speed = 113 knots (IAS)
G. Runway slope = .02 uphill.
H. Refusal speed with slope, no wind = 98.5 knots.
I. Wind = 20 knots headwind (50 percent of reported headwind.)
J. Refusal speed with wind and slope = 109.5 knots (IAS).
K. RCR = 15.
L. Refusal speed corrected for slope, wind and RCR = 100.5 knots (IAS).

NOTE:
Whenever takeoff speed (corrected for crosswind as necessary) is less than corrected refusal speed, use takeoff speed for refusal speed.

Figure A3-8. Takeoff Performance - Refusal Speed - Brakes Only (Sheet 1 of 2)

TAKEOFF PERFORMANCE – REFUSAL SPEED
BRAKES ONLY
2800 RPM
WING FLAPS 20 DEGREES

MODEL: C-118A
DATA AS OF: 10-15-64
DATA BASIS: CALCULATED

ENGINES: (4) R2800-52W

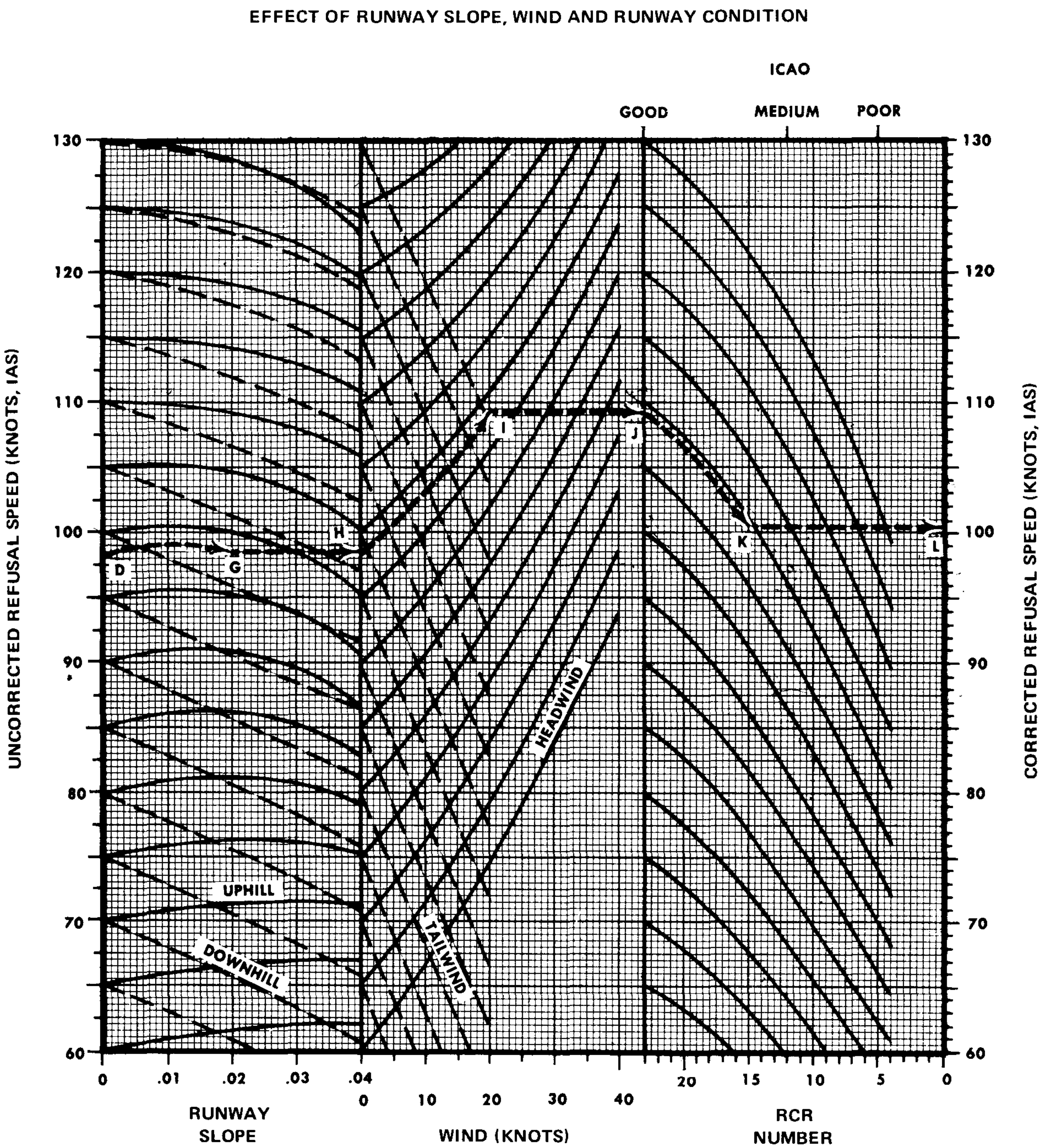


Figure A3-8. Takeoff Performance - Refusal Speed - Brakes Only (Sheet 2 of 2)

TAKEOFF PERFORMANCE – REFUSAL SPEED BRAKES PLUS TWO-ENGINE REVERSE THRUST

2800 RPM

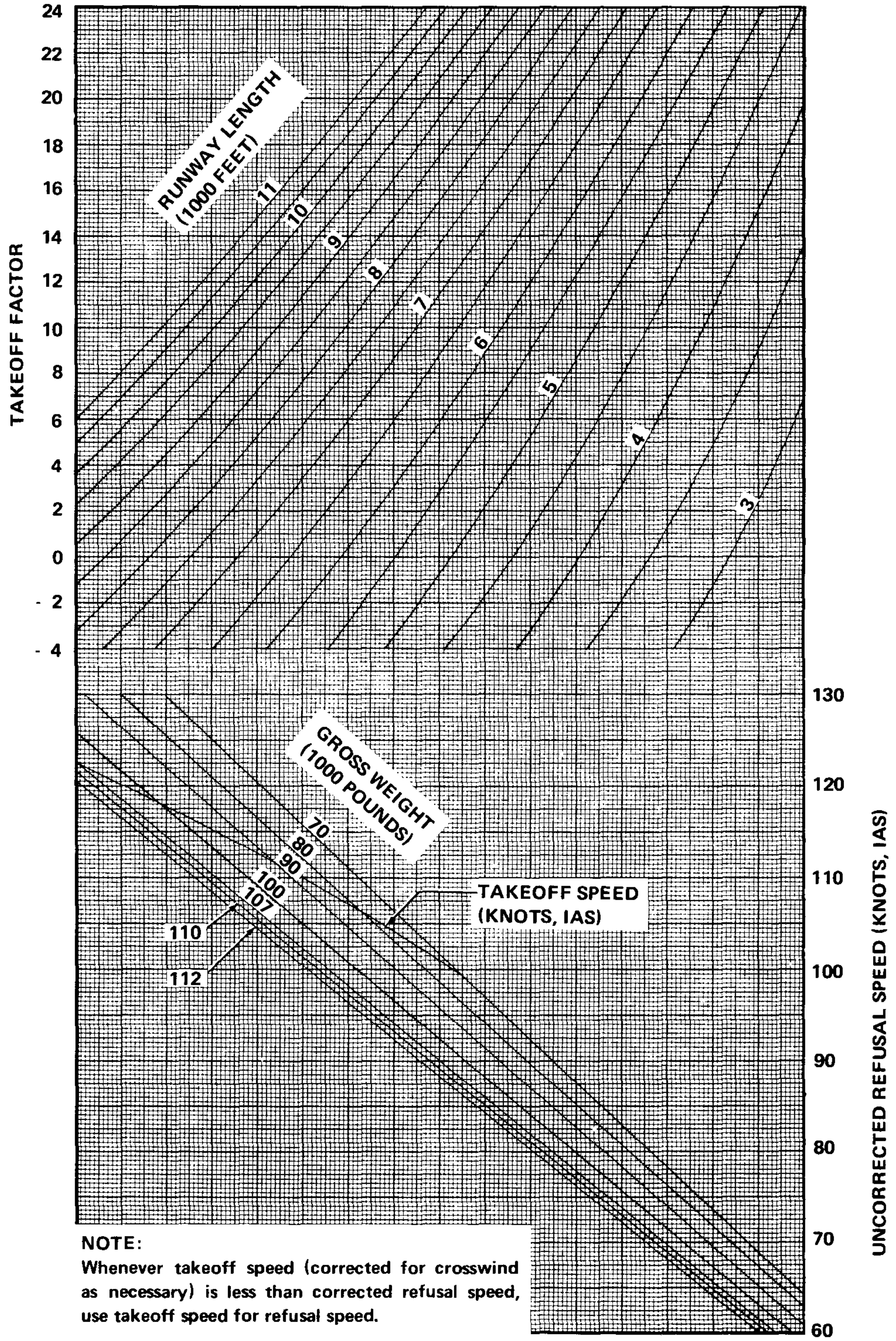
WING FLAPS 20 DEGREES

MODEL: C-118A

DATA AS OF: NOV 1972

DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W



NOTE:
Whenever takeoff speed (corrected for crosswind as necessary) is less than corrected refusal speed, use takeoff speed for refusal speed.

Figure A3-9. Takeoff Performance - Refusal Speed - Brakes Plus Two-Engine Reverse Thrust (Sheet 1 of 2)

TAKEOFF PERFORMANCE – REFUSAL SPEED
BRAKES PLUS TWO-ENGINE REVERSE THRUST

2800 RPM

WING FLAPS 20 DEGREES

MODEL: C-118A
DATA AS OF: 10-15-64
DATA BASIS: CALCULATED

ENGINES: (4) R2800-52W

EFFECT OF RUNWAY SLOPE, WIND AND RUNWAY CONDITION

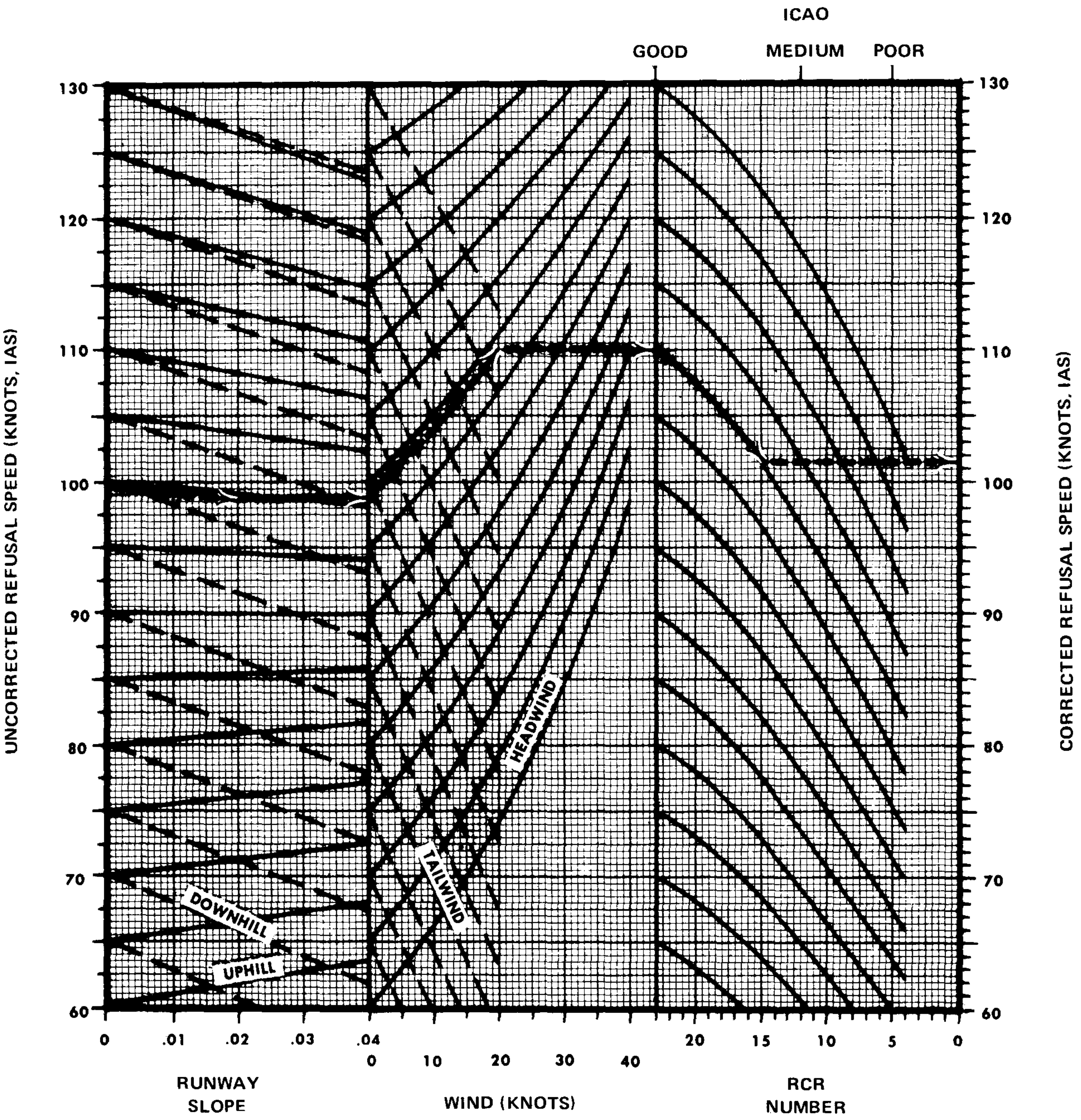


Figure A3-9. Takeoff Performance - Refusal Speed - Brakes Plus Two-Engine Reverse Thrust (Sheet 2 of 2)

TAKEOFF PERFORMANCE – DISTANCE AND TIME VERSUS SPEED
FOUR-ENGINE GROUND RUN

MODEL: C118A
DATE: MAR 1973
DATA BASIS: FLIGHT TEST

ENGINES (4) R2800-52W

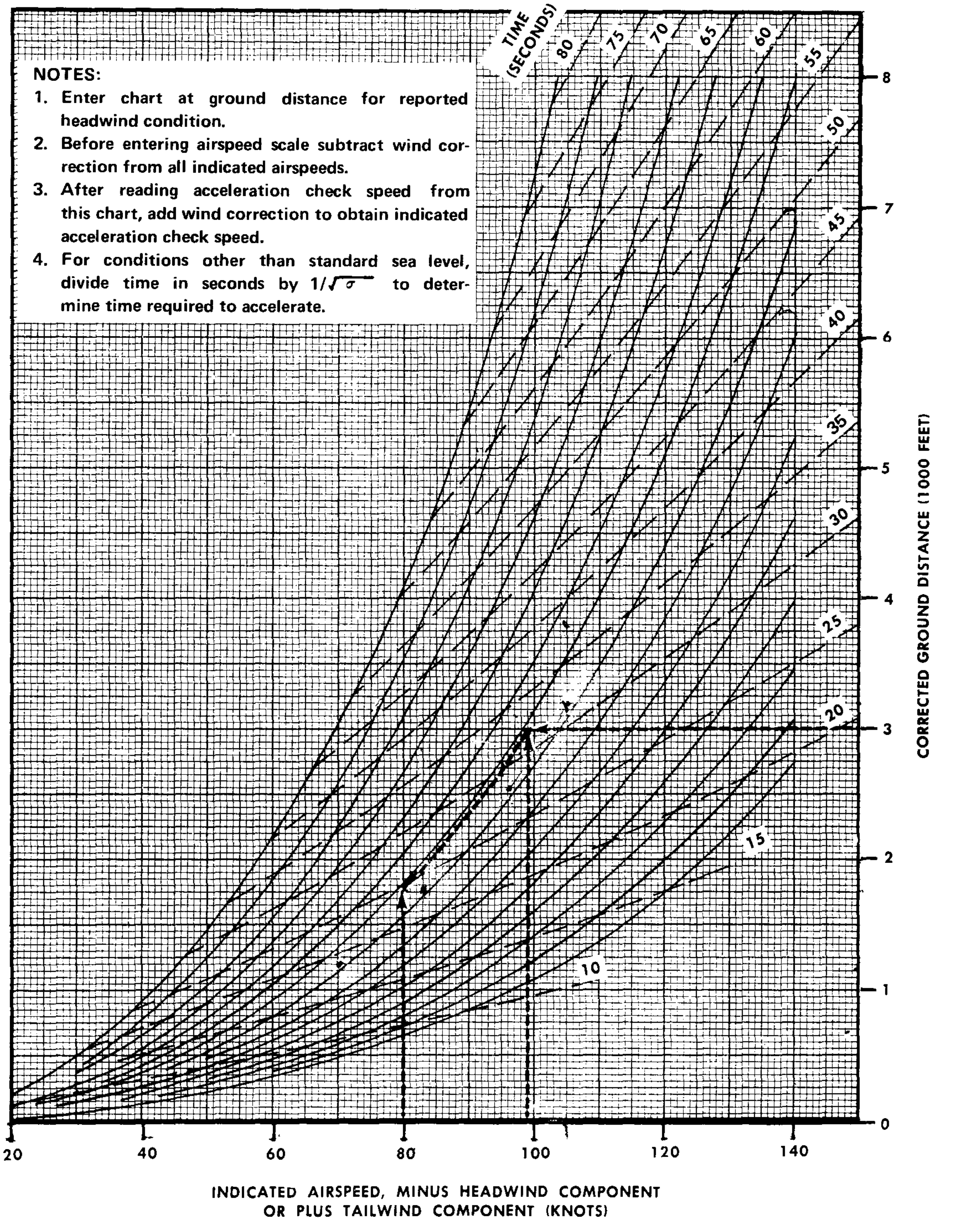


Figure A3-10. Takeoff Performance - Distance and Time Versus Speed

CLIMBOUT FACTOR – FOUR-ENGINE
GROUND EFFECT NOT INCLUDED

MODEL: C-118A
DATA AS OF: NOV 72
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

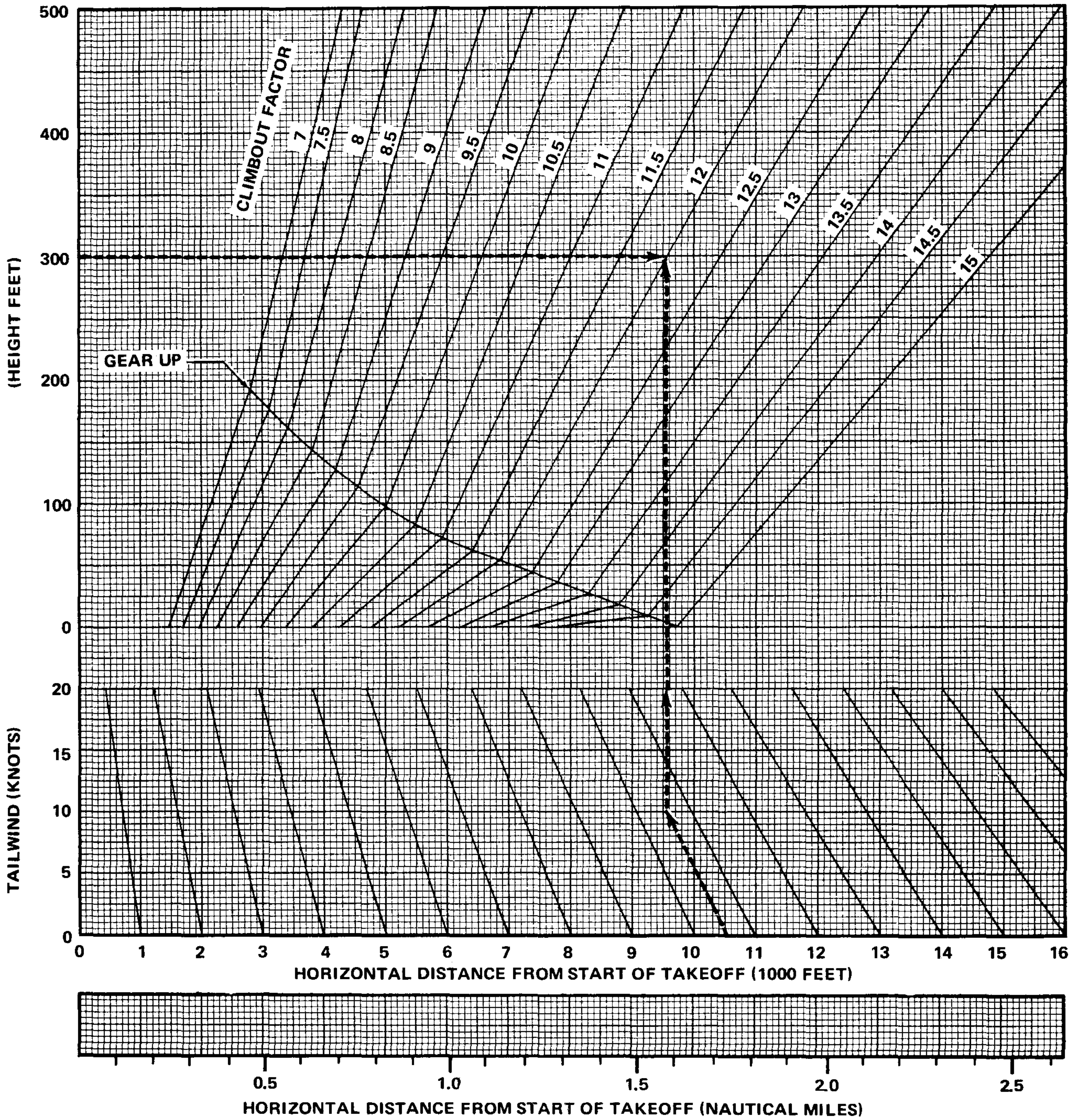


Figure A3-11. Climbout Factor - Four-Engine - Ground Effect Not Included (Sheet 1 of 2)

CLIMBOUT FACTOR – FOUR ENGINE

GROUND EFFECT NOT INCLUDED

400 TO 3600 FT

MODEL: C-118A
DATA AS OF: 12-15-66
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

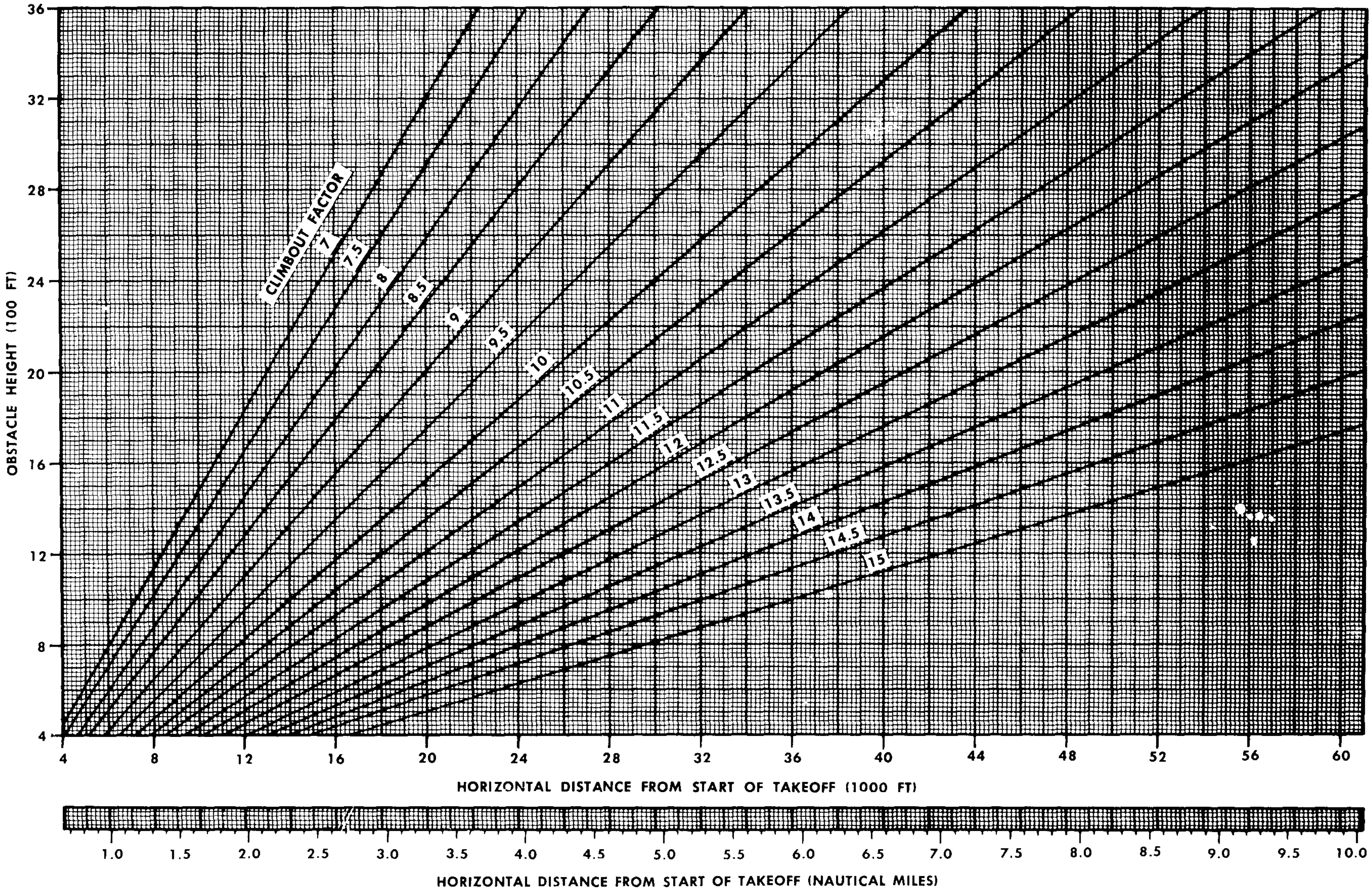


Figure A3-11. Climbout Factor - Four-Engine - Ground Effect Not Included (Sheet 2 of 2)

CLIMBOUT FACTOR – THREE-ENGINE – GROUND EFFECT NOT INCLUDED

ZERO TO 200 FEET

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

SAMPLE PROBLEM:

A. Obstacle distance from start of takeoff = 13500 feet
B. Tailwind = 15 knots
C. Obstacle distance corrected for wind = 11450 feet
D. Obstacle height above runway = 160 feet
E. Climbout factor to clear obstacle = 10.7

NOTE:
With an RCR less than 23 and/or uphill slope, decrease the known distance from the brake, release to the obstacle by the difference between corrected critical field length and critical field length for a dry level runway.

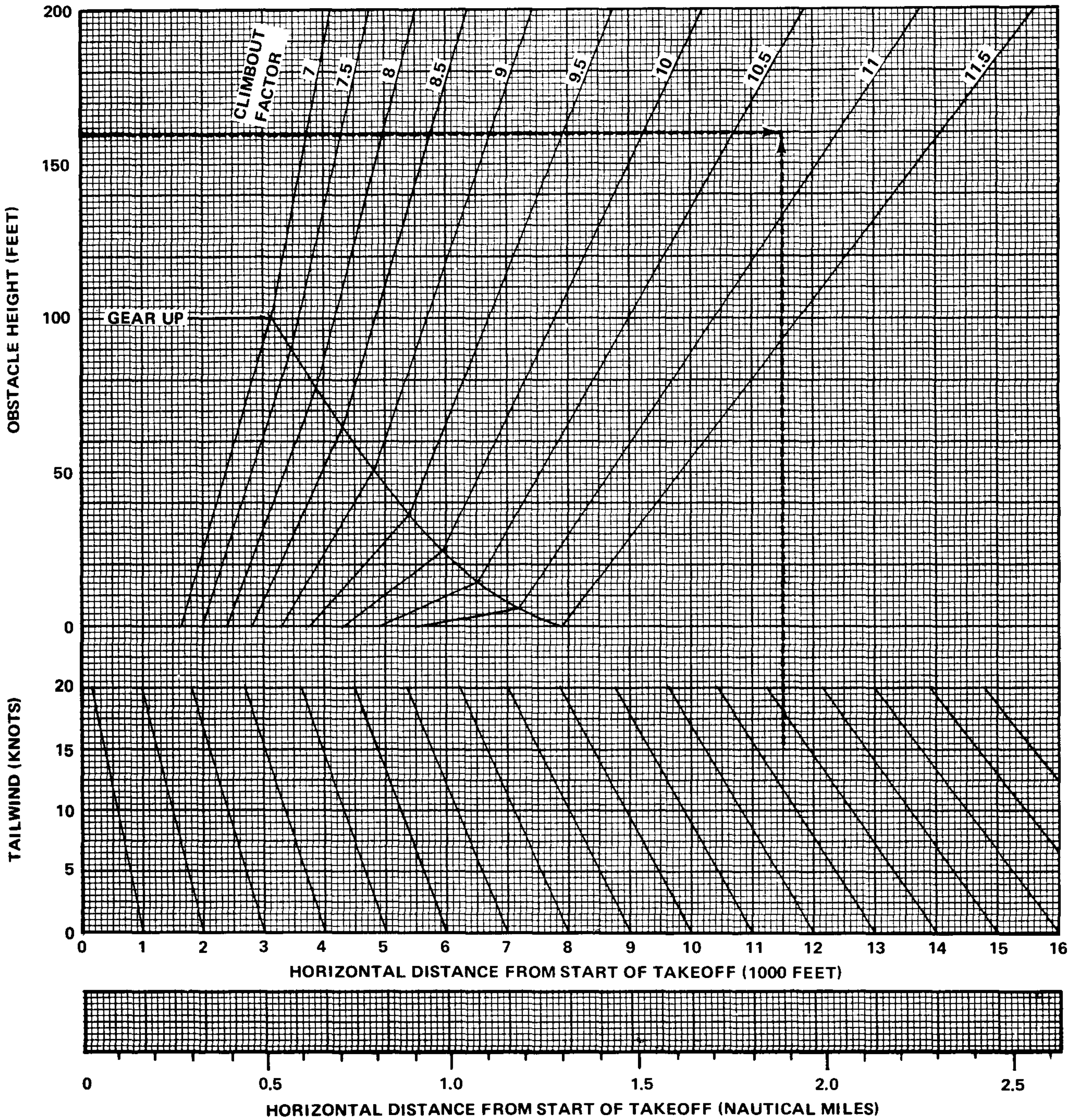


Figure A3-12. Climbout Factor - Three-Engine - Ground Effect Not Included (Sheet 1 of 3)

CLIMBOUT FACTOR – THREE- ENGINE – GROUND EFFECT NOT INCLUDED

200 TO 500 FEET

MODEL C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

SAMPLE PROBLEM:

A. Obstacle distance = 16,500 feet
B. Wind = 10 knots (tailwind)
C. Climbout factor = 10
D. Altitude over obstacle = 388 feet

NOTE:
With an RCR less than 23 and/or uphill slope, decrease the known distance from the brake release to the obstacle by the difference between corrected critical field length and critical field length for a dry level runway.

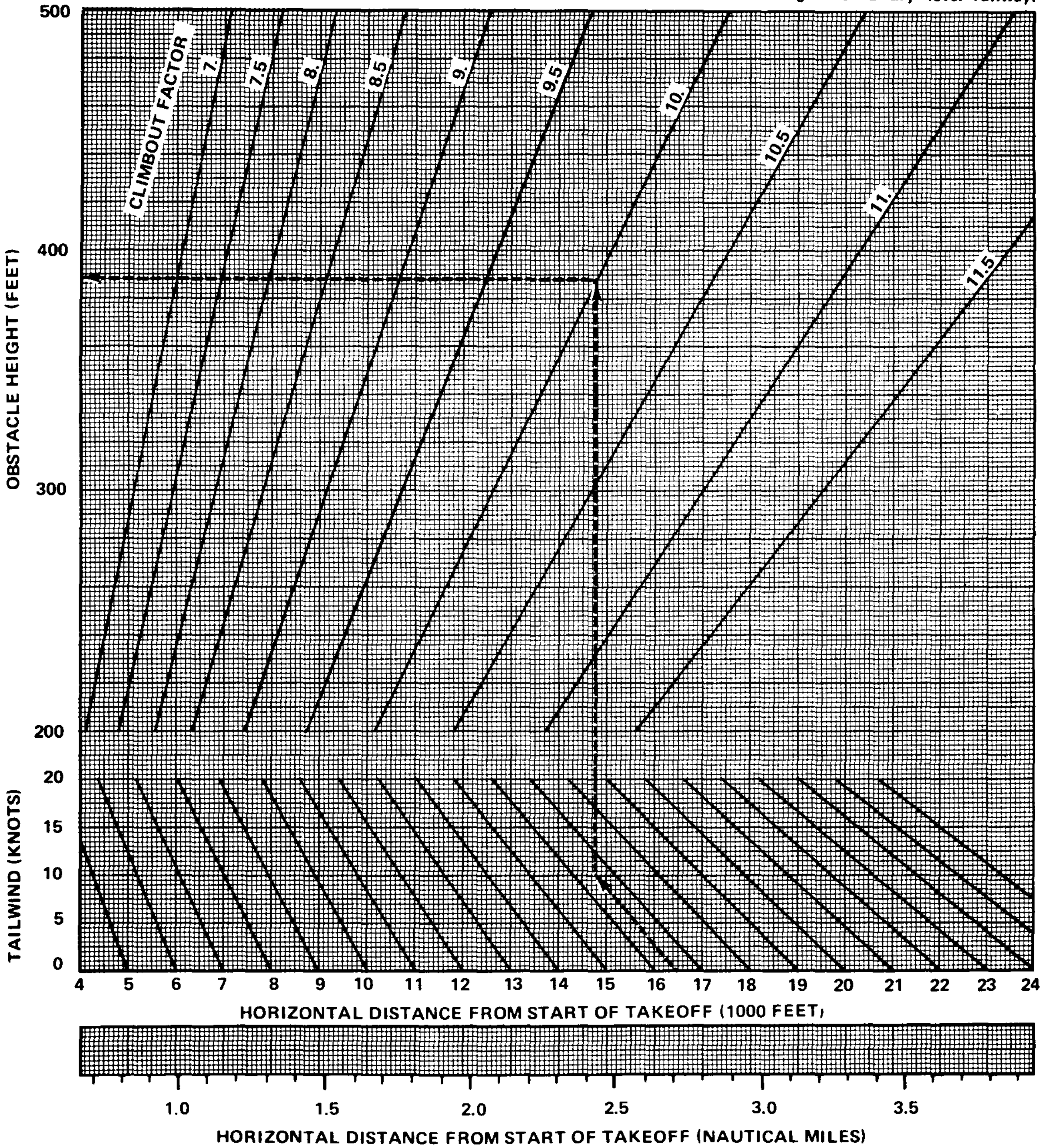


Figure A3-12. Climbout Factor - Three-Engine - Ground Effect Not Included (Sheet 2 of 3)

CLIMBOUT FACTOR – THREE-ENGINE
GROUND EFFECT NOT INCLUDED
400 TO 3600 FEET

MODEL: C-118A
DATA AS OF: 12-15-66
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

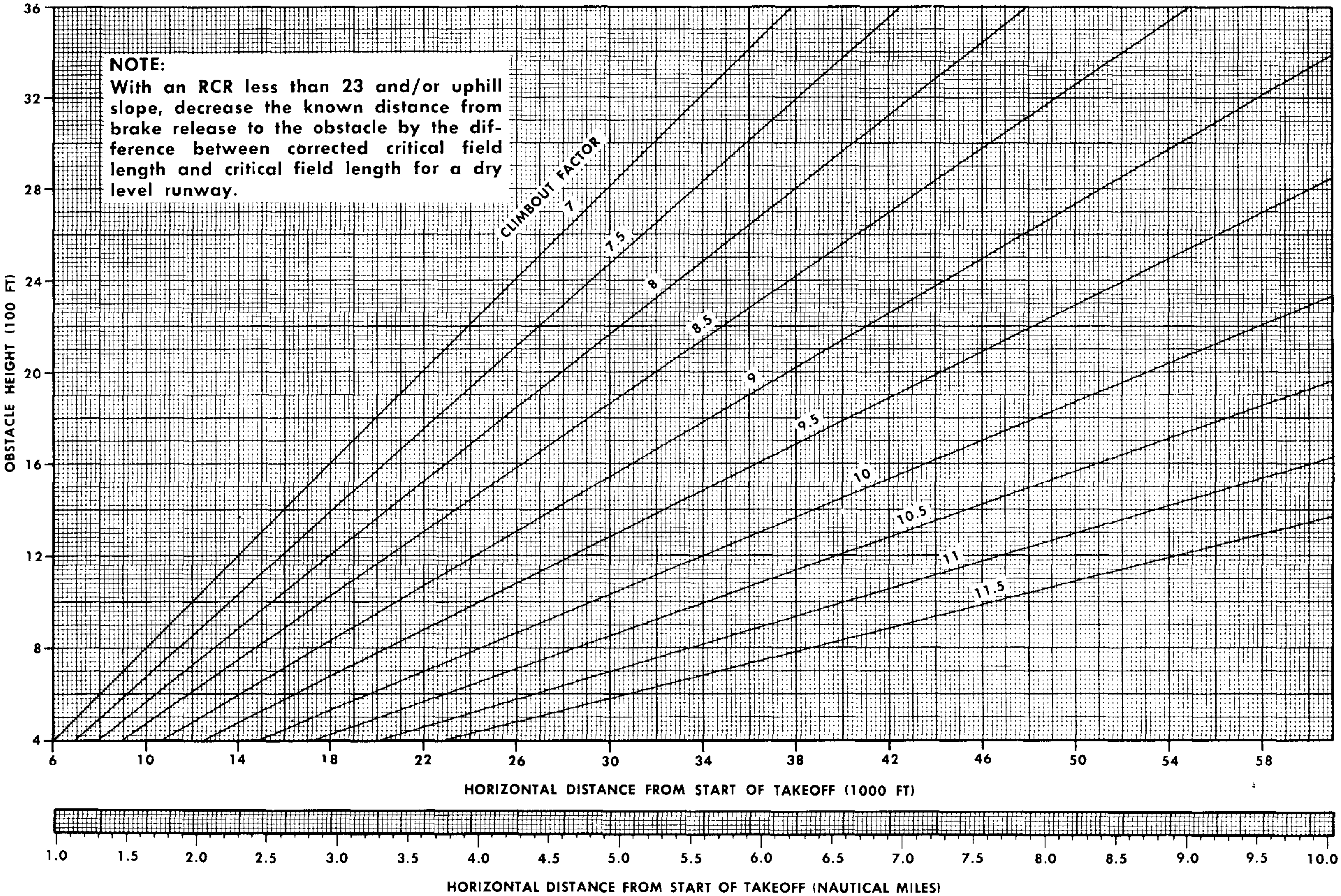


Figure A3-12. Climbout Factor - Three-Engine - Ground Effect Not Included (Sheet 3 of 3)

CLIMBOUT FACTOR – THREE-ENGINE GROUND EFFECT INCLUDED
ZERO TO 200 FEET

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
With an RCR less than 23 and/or uphill slope, decrease the known distance from brake release to the obstacle by the difference between corrected critical field length and critical field length for a dry level runway.

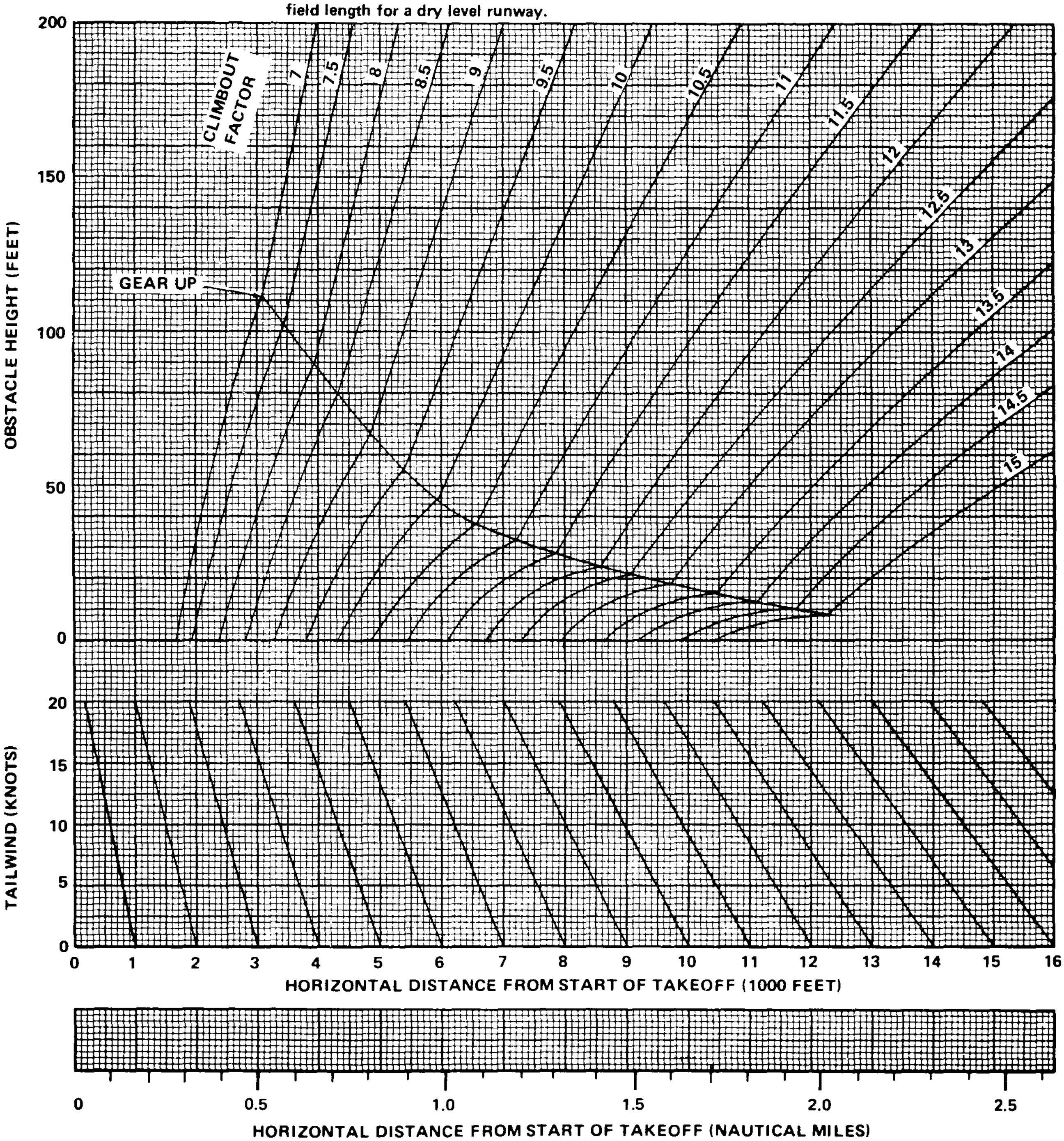


Figure A3-13. Climbout Factor - Three-Engine - Ground Effect Included (Sheet 1 of 3)

CLIMBOUT FACTOR – THREE-ENGINE GROUND EFFECT INCLUDED
200 TO 500 FEET

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
With an RCR less than 23 and/or uphill slope, decrease the known distance from brake release to the obstacle by the difference between the corrected critical field length and critical field length for a dry level runway.

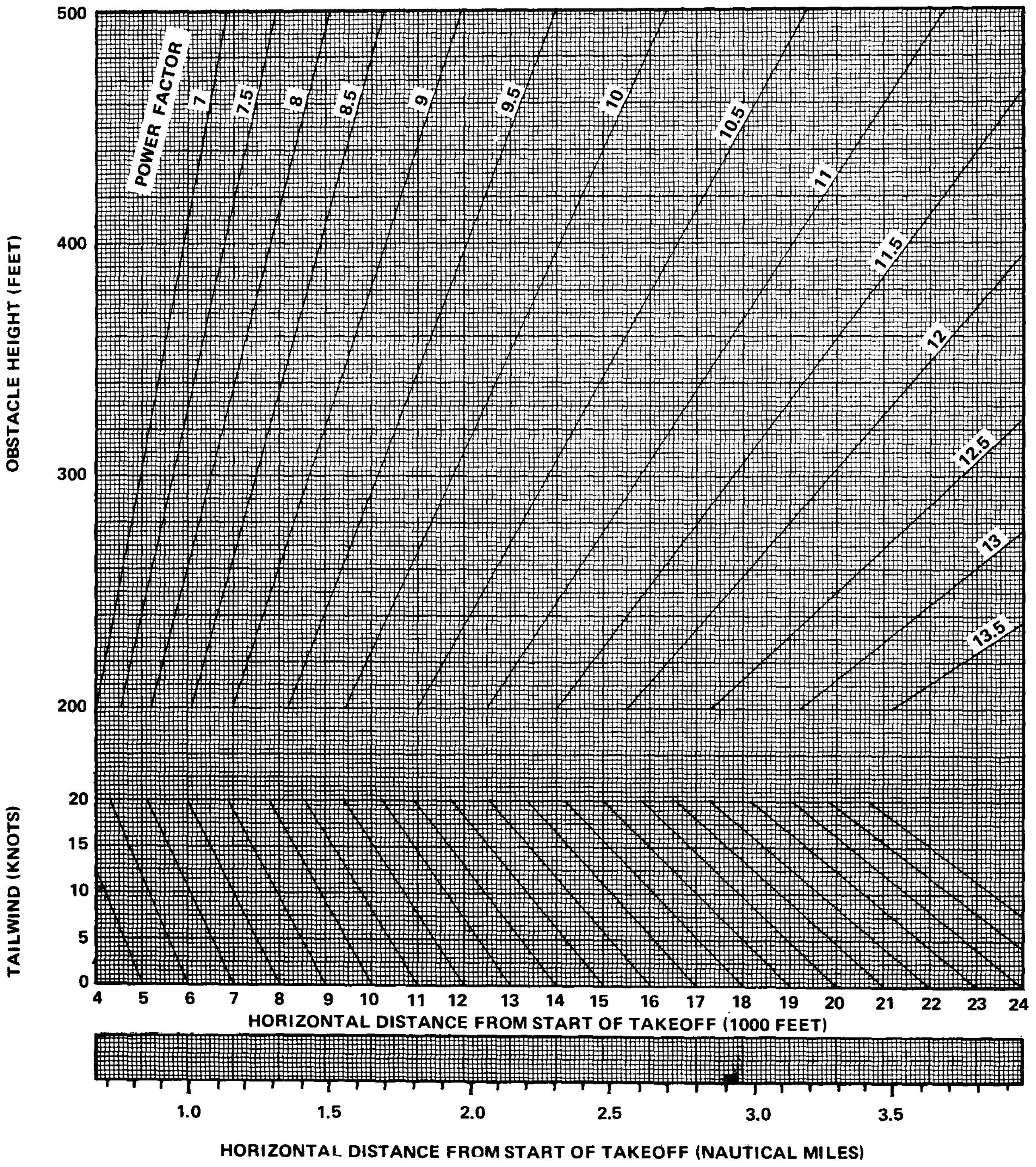


Figure A3-13. Climbout Factor - Three-Engine - Ground Effect Included (Sheet 2 of 3)

MODEL: C-118A
DATA AS OF: 12-15-66
DATA BASIS: FLIGHT TEST

CLIMBOUT FACTOR – THREE ENGINE

GROUND EFFECT INCLUDED

200 TO 3600 FEET

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

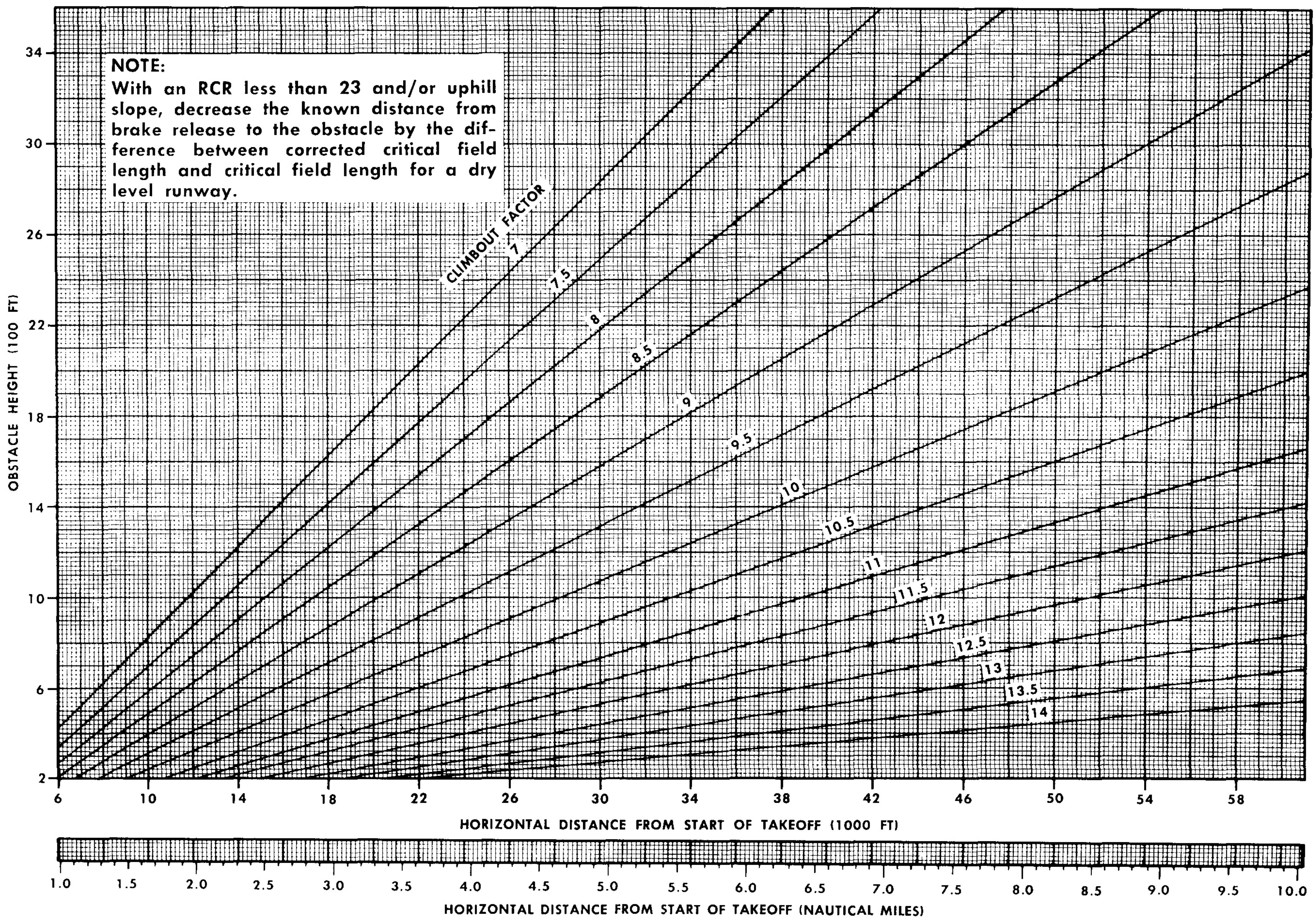


Figure A3-13. Climbout Factor - Three-Engine - Ground Effect Included (Sheet 3 of 3)

GROSS WEIGHT LIMITED BY CLIMBOUT OVER OBSTACLE

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

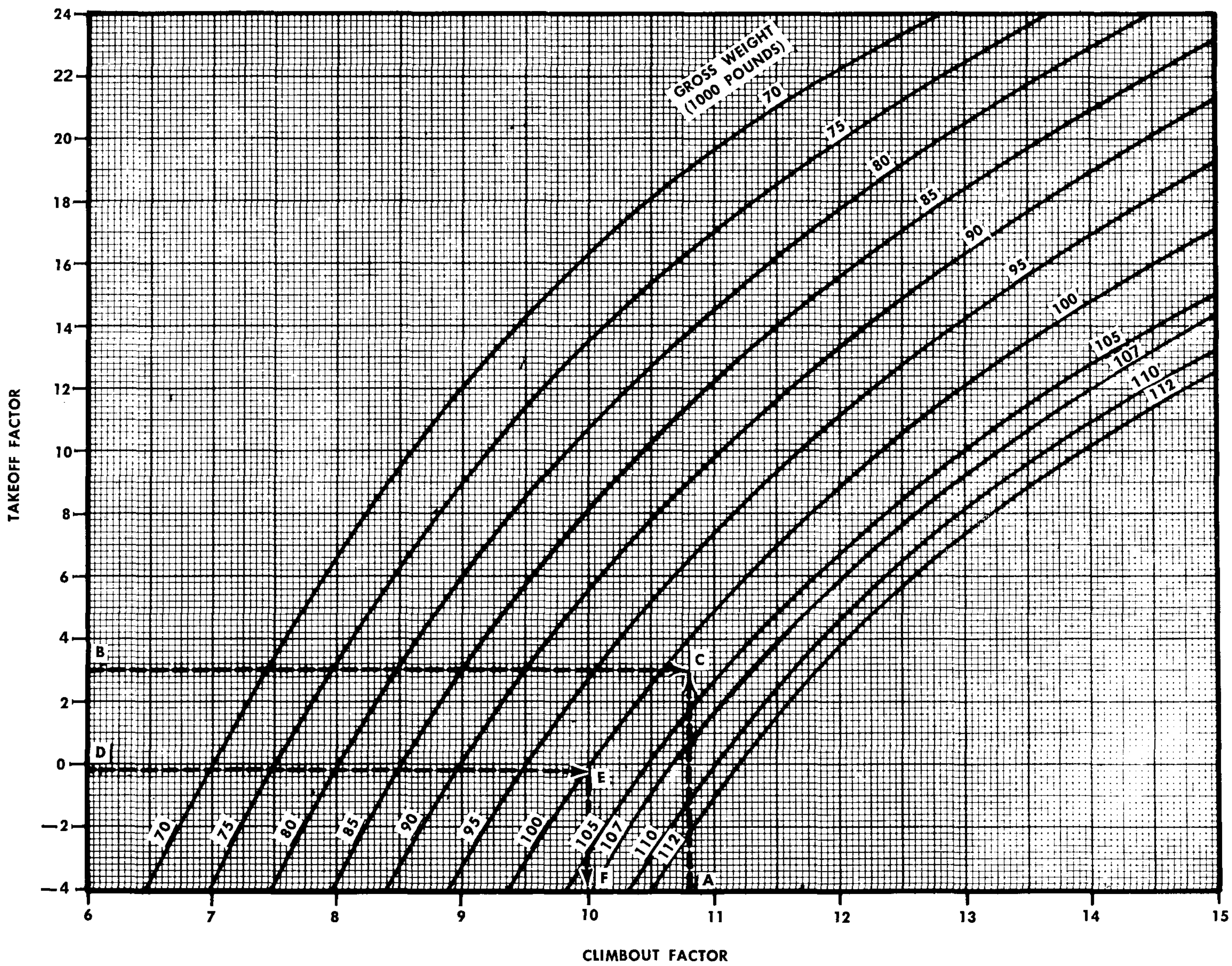


Figure A3-14. Gross Weight Limited By Climbout Over Obstacle

TAKEOFF DISTANCE TO A 50-FOOT HEIGHT
THREE-ENGINE FERRY CONFIGURATION
ONE ENGINE INOPERATIVE, PROPELLER FEATHERED OR REMOVED

MODEL: C-118A
DATA AS OF: NOV 1972
BASED ON: CALCULATED DATA

ENGINE(S): (4) R2800-52W

HARD SURFACE RUNWAY NO WIND
WING FLAPS 20 DEGREES
STANDARD ATMOSPHERIC CONDITIONS
NO OBSTACLE AT END OF RUNWAY

NO RUNWAY SLOPE
COWL FLAPS =
INOPERATIVE ENGINE, CLOSED (−4 DEGREES)
OPERATIVE ENGINE, OPEN (+3 DEGREES)

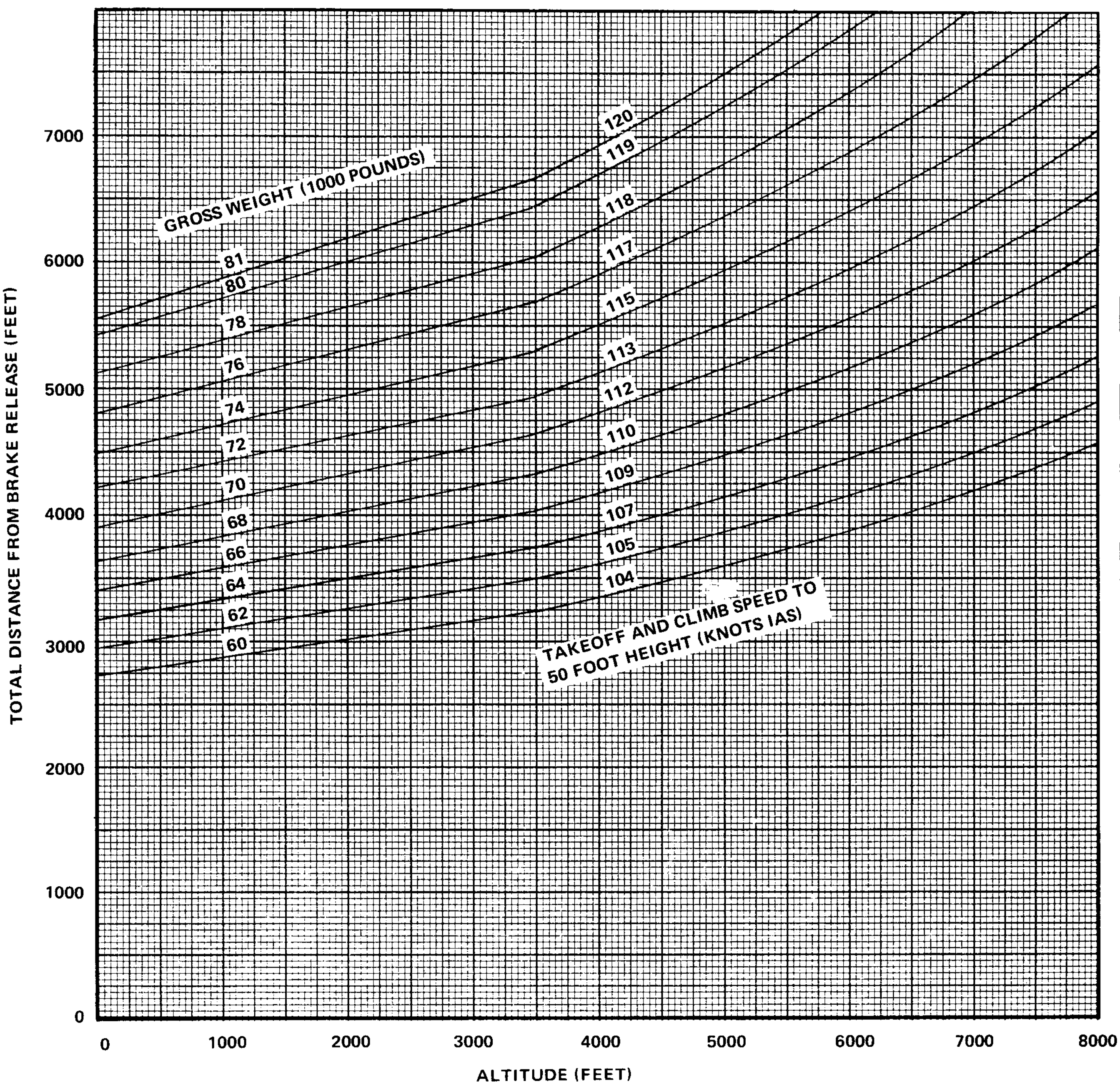


Figure A3-15. Takeoff Distance to a 50-Foot Height, Three-Engine Ferry Configuration

DISTANCE TO STOP
BRAKES ONLY – PROPELLERS WINDMILLING

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W

RUNWAY SURFACE CONDITION	ICAO	RUNWAY CONDITION READING (RCR)
DRY SURFACE OR MACADAM	GOOD	23
DRY TURF		15
WET CONCRETE OR MACADAM	MEDIUM	12
SNOW OR WET GRASS		08
ICE	POOR	05

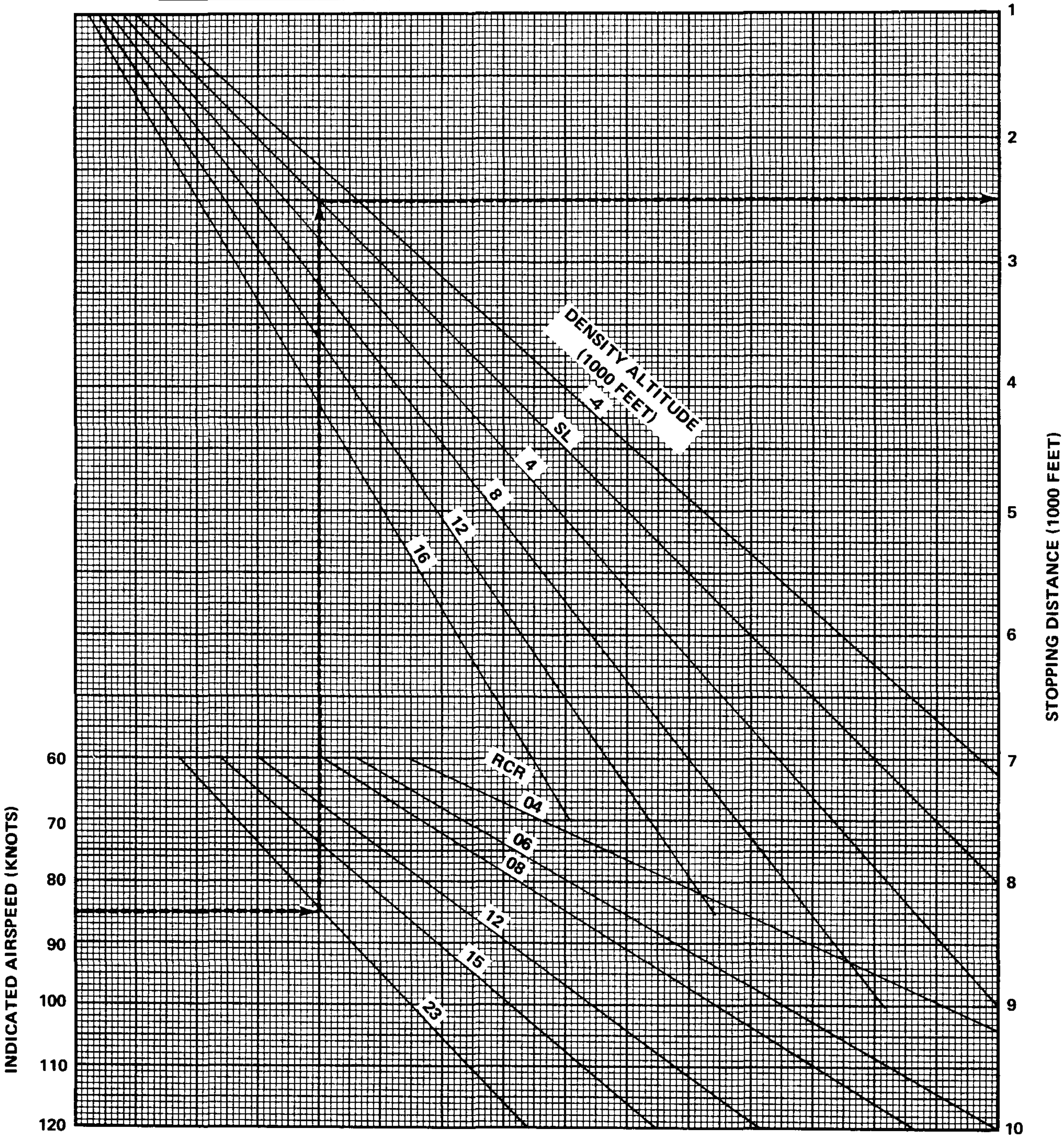


Figure A3-16. Distance to Stop - Brakes Only - Propellers Windmilling

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

DISTANCE TO STOP
BRAKES PLUS TWO-ENGINE REVERSE THRUST

ENGINES: (4) R2800-52W

RUNWAY SURFACE CONDITION	ICAO	RUNWAY CONDITION READING (RCR)
DRY CONCRETE OR MACADAM	GOOD	23
DRY TURF		15
WET CONCRETE OR MACADAM	MEDIUM	12
SNOW OR WET GRASS		08
ICE	POOR	05

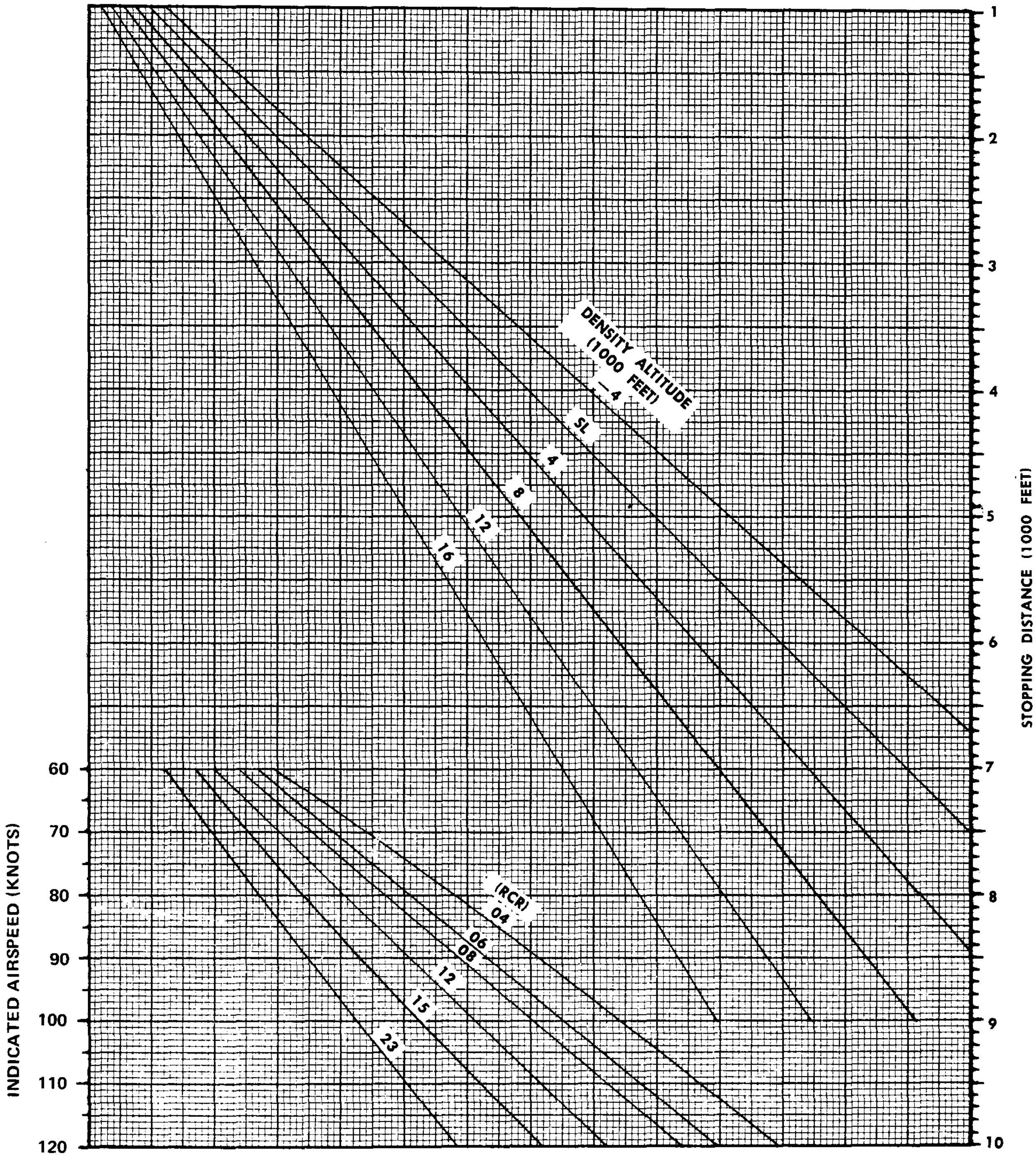


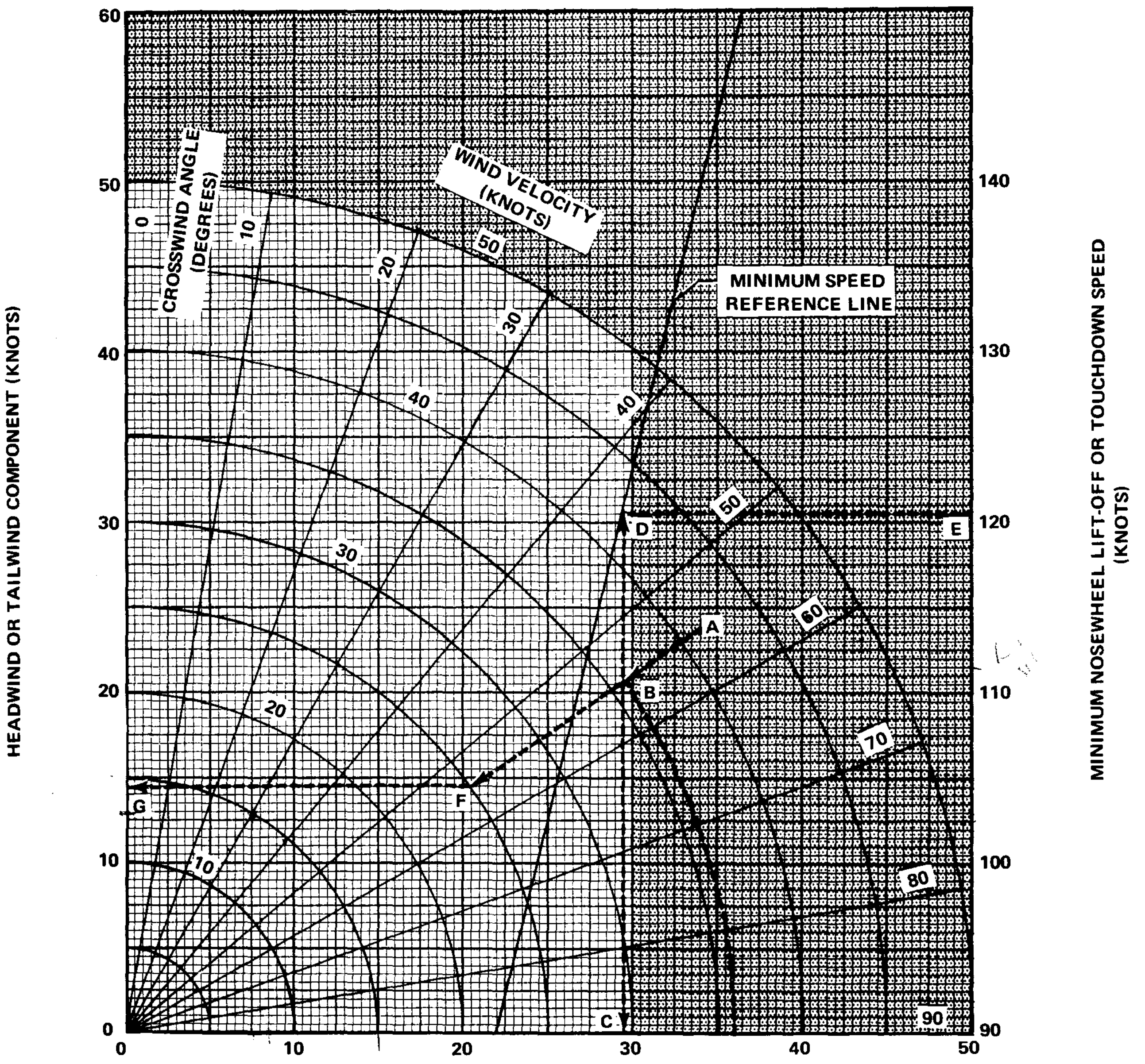
Figure A3-17. Distance to Stop - Brakes Plus Two-Engine Reverse Thrust

TAKEOFF AND LANDING CROSSWIND

MODEL: C118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W

LEGEND:
Authorized
Not recommended



NOTES:

1. Enter chart with maximum gust velocity for crosswind and tailwind components.
2. Use maximum steady wind velocity for headwind component.
3. Whenever minimum nosewheel liftoff or touchdown speed is increased due to crosswind component, the takeoff ground run or landing ground roll must be corrected for new speed.

Figure A3-18. Takeoff and Landing Crosswind

MINIMUM CONTROL SPEED VS BANK ANGLE

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: ESTIMATED

ENGINES (4) R2800-52W

NOTE:
1. BASED ON ONE OUTBOARD ENGINE INOPERATIVE, PROPELLER WINDMILLING
2. THREE ENGINES OPERATING AT 2500 BHP/ENG.
3. WING FLAPS 20 DEGREES

SAMPLE PROBLEM:
A. BANK ANGLE = 4 DEGREES
B. GROSS WEIGHT = 73,000 LBS.
C. MINIMUM CONTROL SPEED = 94 KIAS

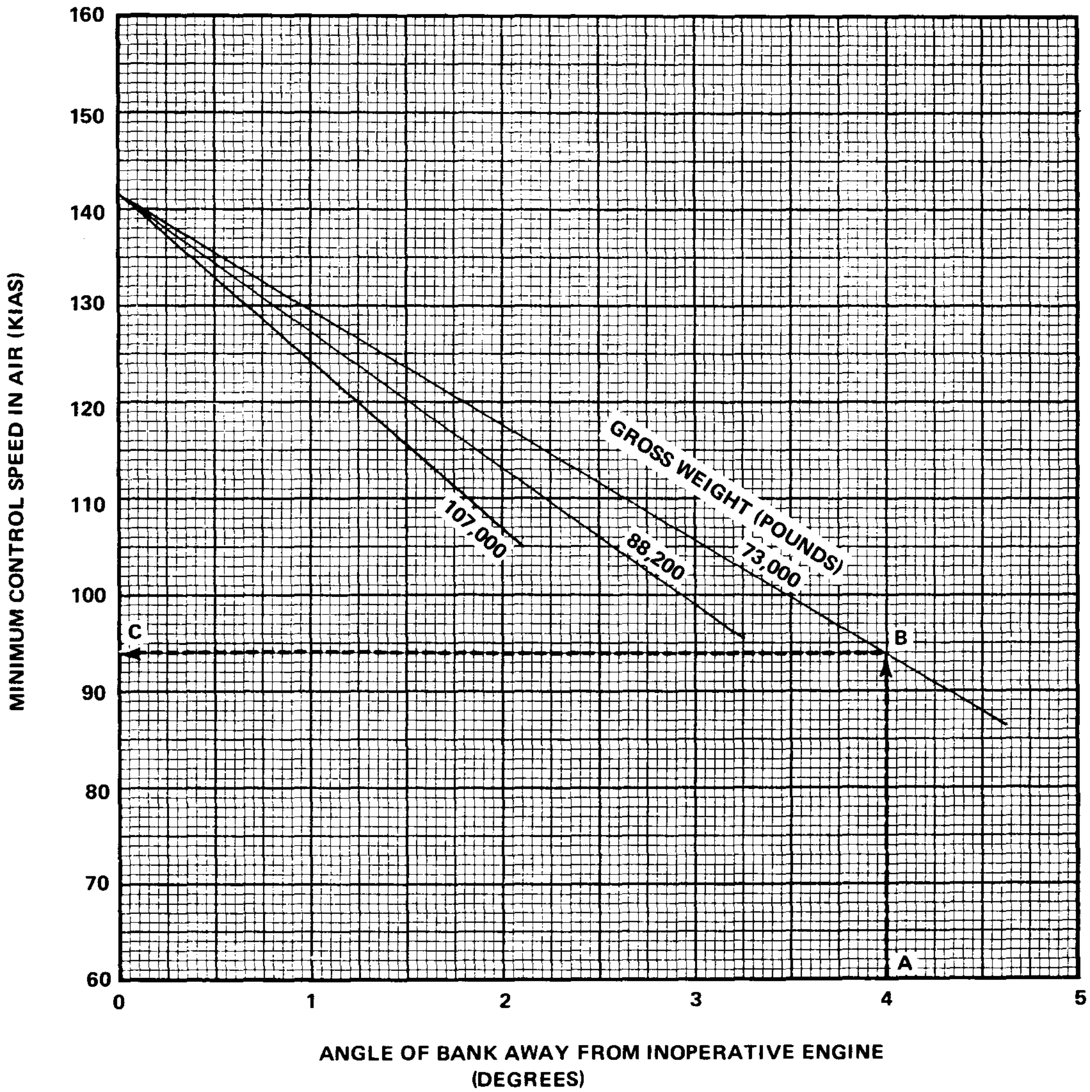


Figure A3-19. Minimum Control Speed Vs Bank Angle

part 4
climb

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

DISCUSSION OF CHARTS.

TIME, DISTANCE, AND FUEL TO CLIMB CHARTS.

Two charts are provided (figures A4-1 and A4-2) from which may be determined the time elapsed, distance traveled and fuel consumed during an operational climb from sea level to cruise altitude. One chart is for 1400 brake horsepower per engine and the other is for 1500. In both cases the power is assumed to be constant from sea level up to the altitude at which that power may only be obtained with full throttle and 2600 RPM. Above that altitude power is assumed to decrease as the engine settings remain at full throttle and 2600 RPM. Altitudes shown on the charts are density altitudes, therefore no correction for temperature is necessary.

Examples are shown on each chart to illustrate the method of determining climb data, figure A4-1 showing climb from sea level to cruise altitude, and figure A4-2 showing climb from an intermediate altitude to cruise altitude.

EMERGENCY CEILING CHARTS.

Two charts are provided (figures A4-3 and A4-4) showing the altitude at which 100 feet per minute rate of climb may be maintained with METO power at any given gross weight. One chart is for standard fuel grade and the other is for alternate fuel grade. On both charts there are curves for four engines, three engines and two engines operating. Grids are included to permit corrections to be made for hotter than standard temperatures. The charts are based on a clean configuration and airspeed of 138 KIAS, to obtain optimum climb.

EMERGENCY CLIMB CHARTS.

The Emergency Climb charts (figures A4-5 through A4-13) indicate the rate of climb at various combinations of power, indicated airspeed, gross weight and density altitudes. Charts are provided for both four- and three-engine operation in the takeoff configuration with the gear up and with the gear down, enroute configuration (flaps and gear up), and in the landing configuration (flaps full down and gear down).

A chart is also provided for two-engine operation in the enroute configuration. No chart is provided for two-engine operation in the landing configuration since a negative rate of climb exists during two-engine operation with both flaps and gear down.

The charts are based on operation in low blower at 2800 RPM. Where necessary to use high blower for climb, high blower BMEP must be converted to an equivalent low blower BMEP before entering the chart. Equivalent BMEP may be obtained from the high blower Brake Horsepower Available For Takeoff charts (figures A2-6 and A2-7), or by the following formula:

Equivalent BMEP = High Blower BMEP x 0.93.

All charts are based on the cowl flaps at +3 degrees on the operative engines. The three- and two-engine charts are based on the cowl flaps at -4 degrees and the propellers feathered on the inoperative engines. The speeds for best rate of climb and the power off stall speeds for various gross weights are indicated on each chart. A sample problem to illustrate the method of using the charts is included on figure A4-5.

THREE-ENGINE PERFORMANCE CLIMBS CHART.

This chart (figure A4-14) shows the variation of rate of climb vs gross weight for several three-engine configurations. Four of these configurations may occur during the climbout after a takeoff with engine failure and the fifth is the three-engine enroute configuration. They are all based on sea level standard atmospheric conditions. A scale is included to show the takeoff speed vs gross weight.

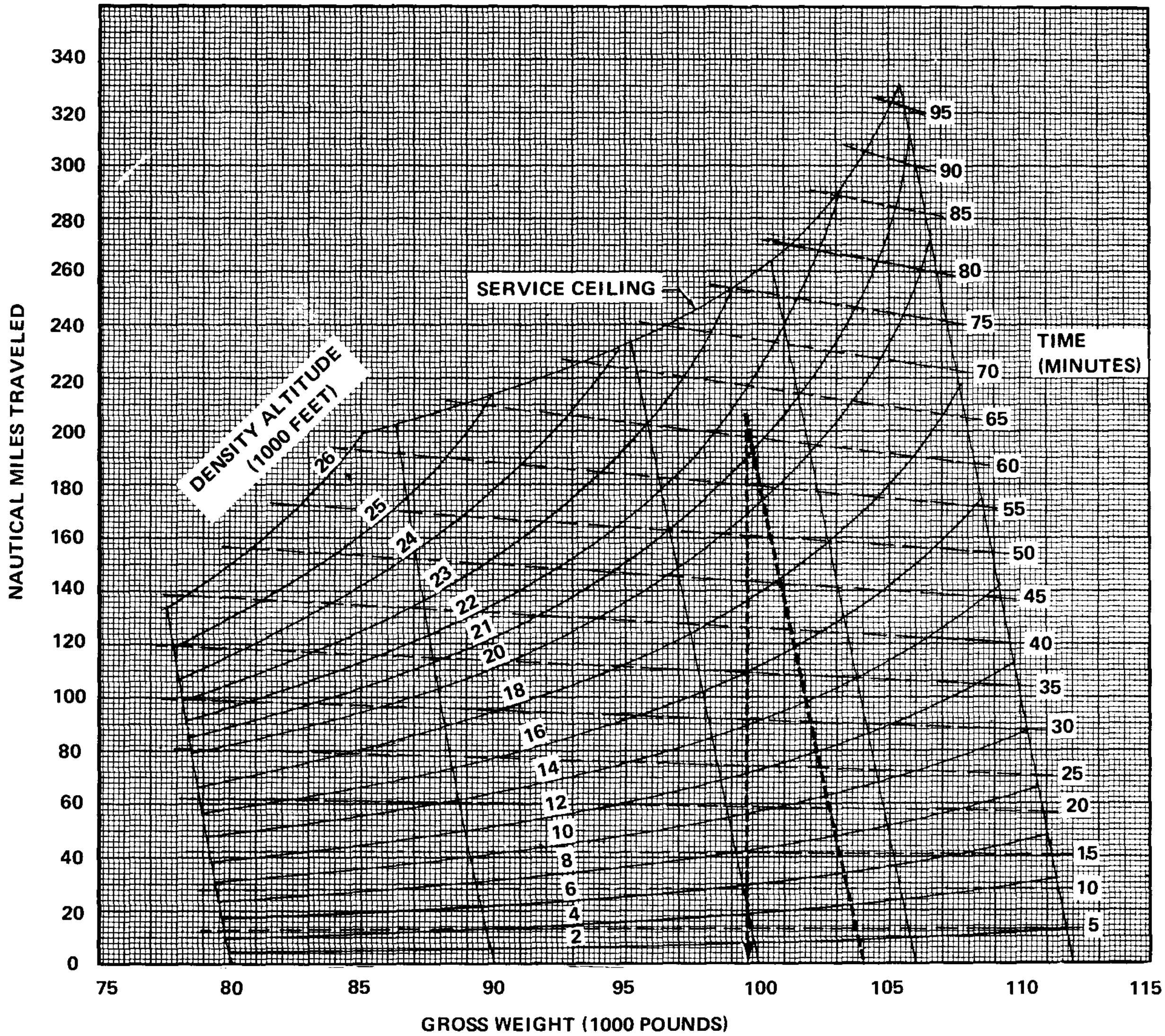
POWER SETTING FOR CLIMB TABLES.

Four tables are provided, tabulating the power settings necessary to maintain climb power for various altitude and carburetor air temperature combinations. The tables are based on a constant RPM and BMEP for a given brake horsepower and show the manifold pressures necessary to maintain the required brake horsepower at a given altitude and carburetor air temperature. The minimum fuel flow for these power settings is shown on each table. Tables are provided for four-engine climb at 1400 BHP/engine (figure A4-15) and 1500 BHP/engine (figure A4-16), and for three- and two-engine climb at 1600 BHP/engine (figure A4-17) and 1700 BHP/engine (figure A4-18).

TIME, DISTANCE, AND FUEL TO CLIMB – 1400 BHP
ALL ENGINES OPERATING – AUTO RICH MIXTURE
CLIMBING AIRSPEED = 161 KNOTS CAS

MODEL: C-118A
DATE: MAR 73
DATA BASIS: FLIGHT TEST

ENGINES (4) R2800-52W



SAMPLE PROBLEM
GIVEN:

1. Gross weight at start of climb = 104,000 pounds.
2. Cruise density altitude = 21,680 Feet
3. Initial climb density altitude = sea level

A. Enter chart at 104,000 pounds gross weight at sea level.
B. Follow contour to 21,680 density altitude. Read time to climb, 63 minutes, and distance traveled 207 nautical miles.
C. Gross weight at end of climb = 99600 pounds. Fuel consumed during climb = 104,000 - 99,600 = 4400 pounds.

NOTE:

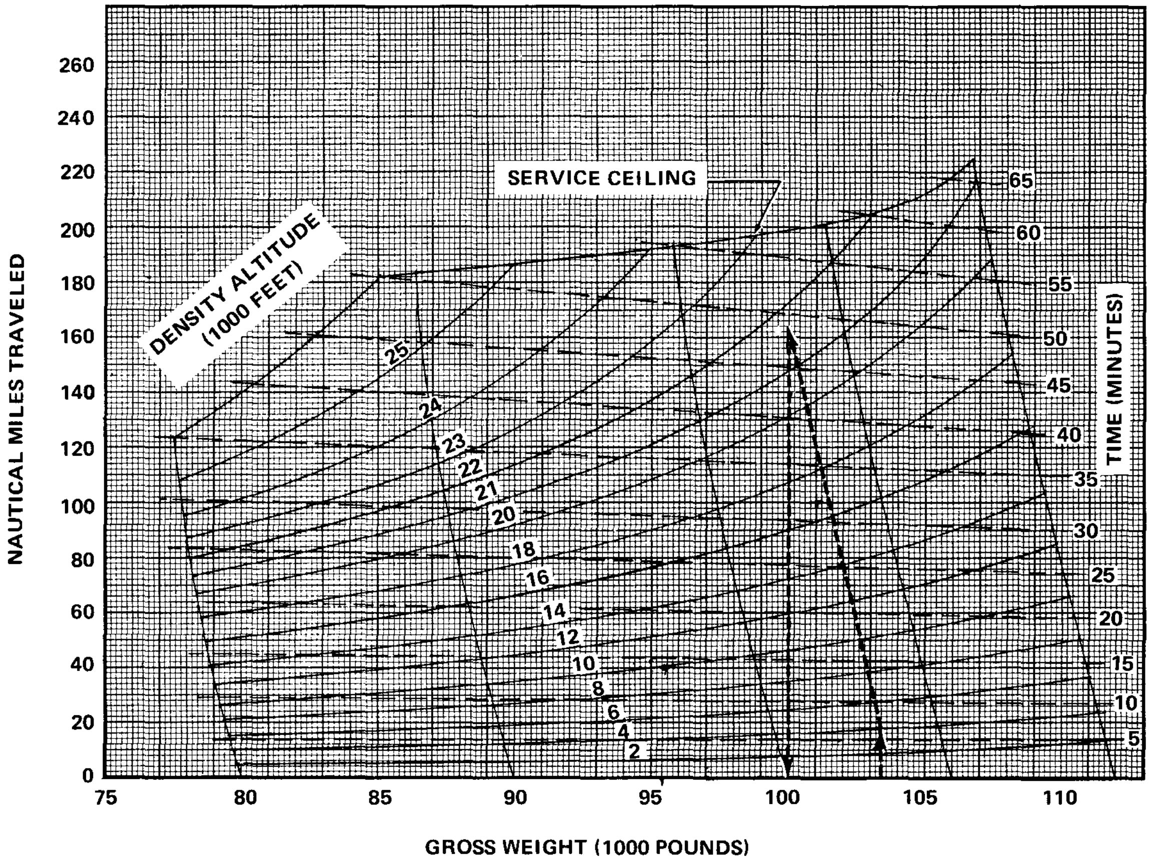
1. Based at 1400 BHP from sea level up to altitude at which full throttle is reached with 2600 RPM in high blower. Based on full throttle and 2600 RPM above that altitude.

Figure A4-1. Time, Distance, and Fuel to Climb - 1400 BHP

TIME, DISTANCE, AND FUEL TO CLIMB – 1500 BHP
ALL ENGINES OPERATING – AUTO RICH MIXTURE
CLIMBING AIRSPEED = 161 KNOTS CAS

MODEL: C-118A
DATA AS OF: MAR 72
DATA BASIS: FLIGHT TEST

ENGINES (4) R2800-52W



NOTE:

1. Based on 1500 BHP from sea level up to altitude at which full throttle is reached with 2600 RMP in high blower. Based on full throttle and 2600 RPM above that altitude.

SAMPLE PROBLEM

GIVEN:

1. Gross weight at start of climb = 103,400 pounds.
2. Initial climb density altitude = 4000 feet.
3. Cruise density altitude = 21,680 feet.

A. Enter chart at 103,400 pounds gross weight and read up to initial climb altitude at 4000 feet.

B. Read time of 7 minutes and distance of 19 nautical miles.

C. Follow contour to cruise altitude of 21,680 feet. Read time to climb of 49 minutes and distance traveled of 164 nautical miles.

D. Gross weight at end of climb = 100,000 pounds.
Fuel to climb = 103,400 -100,000 or 3,400 pounds.
Time to climb = 49-7, or 42 minutes.
Distance to climb = 164-19, or 145 nautical miles.

Figure A4-2. Time, Distance, and Fuel to Climb-1500 BHP

EMERGENCY CEILING
100 FEET PER MINUTE RATE OF CLIMB
METO POWER
CLIMBING SPEED — 138 KNOTS, PILOT'S IAS

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: FLIGHT TEST

SAMPLE PROBLEM:

A. Gross weight = 90,000 pounds.
B. Two engines operating.
C. Temperature = 15°C above standard.
D. Emergency ceiling = 4300 feet pressure altitude.

ENGINE(S): R2800-52W
FUEL GRADE: 115/145

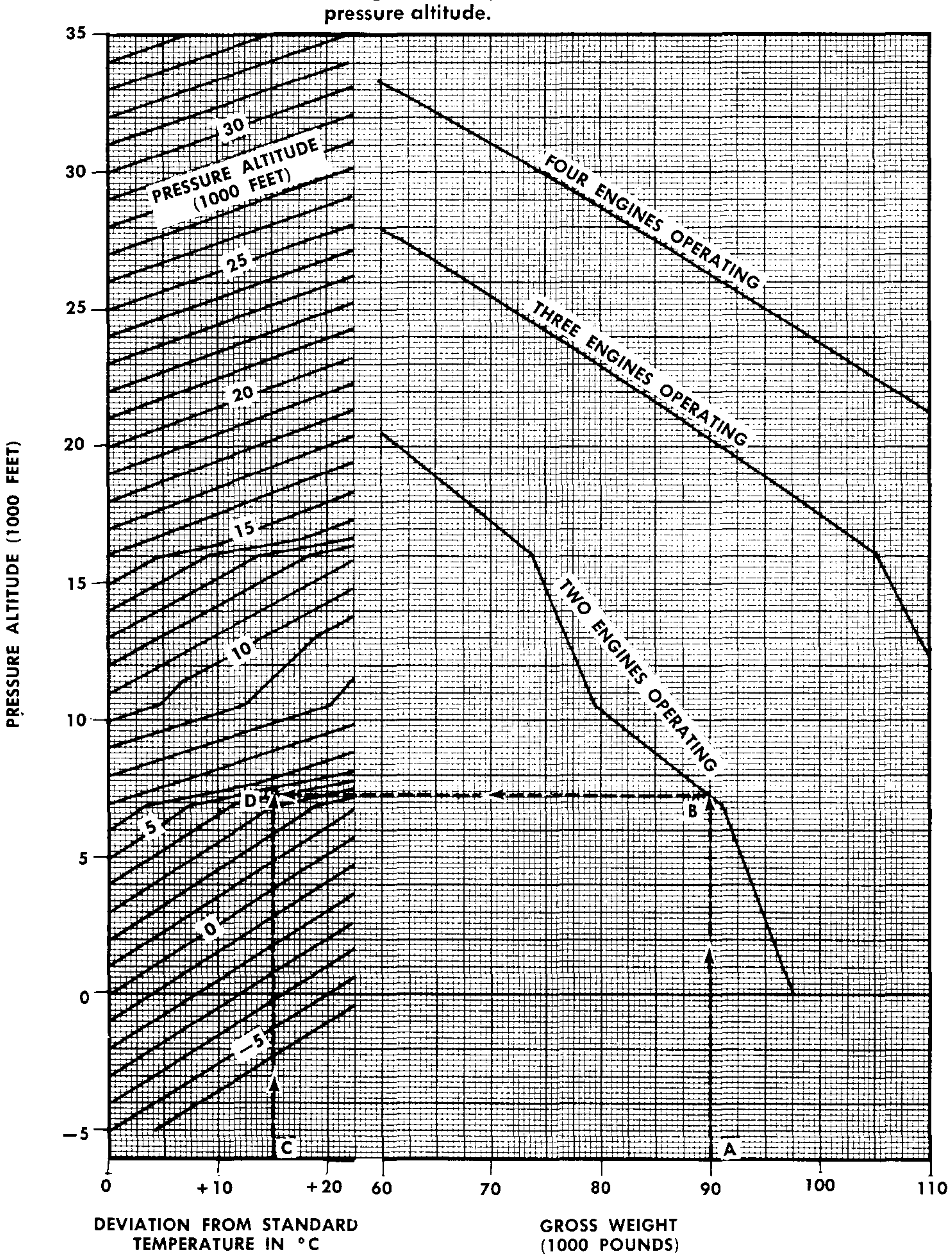


Figure A4-3. Emergency Ceiling - Standard Fuel Grade

EMERGENCY CEILING
100 FEET PER MINUTE RATE OF CLIMB
METO POWER
CLIMBING SPEED – 138 KNOTS, PILOT'S IAS

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: FLIGHT TEST

SAMPLE PROBLEM:
A. Gross weight = 90,000 pounds.
B. Two engines operating.
C. Temperature = 15°C above standard.
D. Emergency ceiling = 400 feet pressure altitude.

ENGINE(S): R2800-52W
FUEL GRADE: 100/130

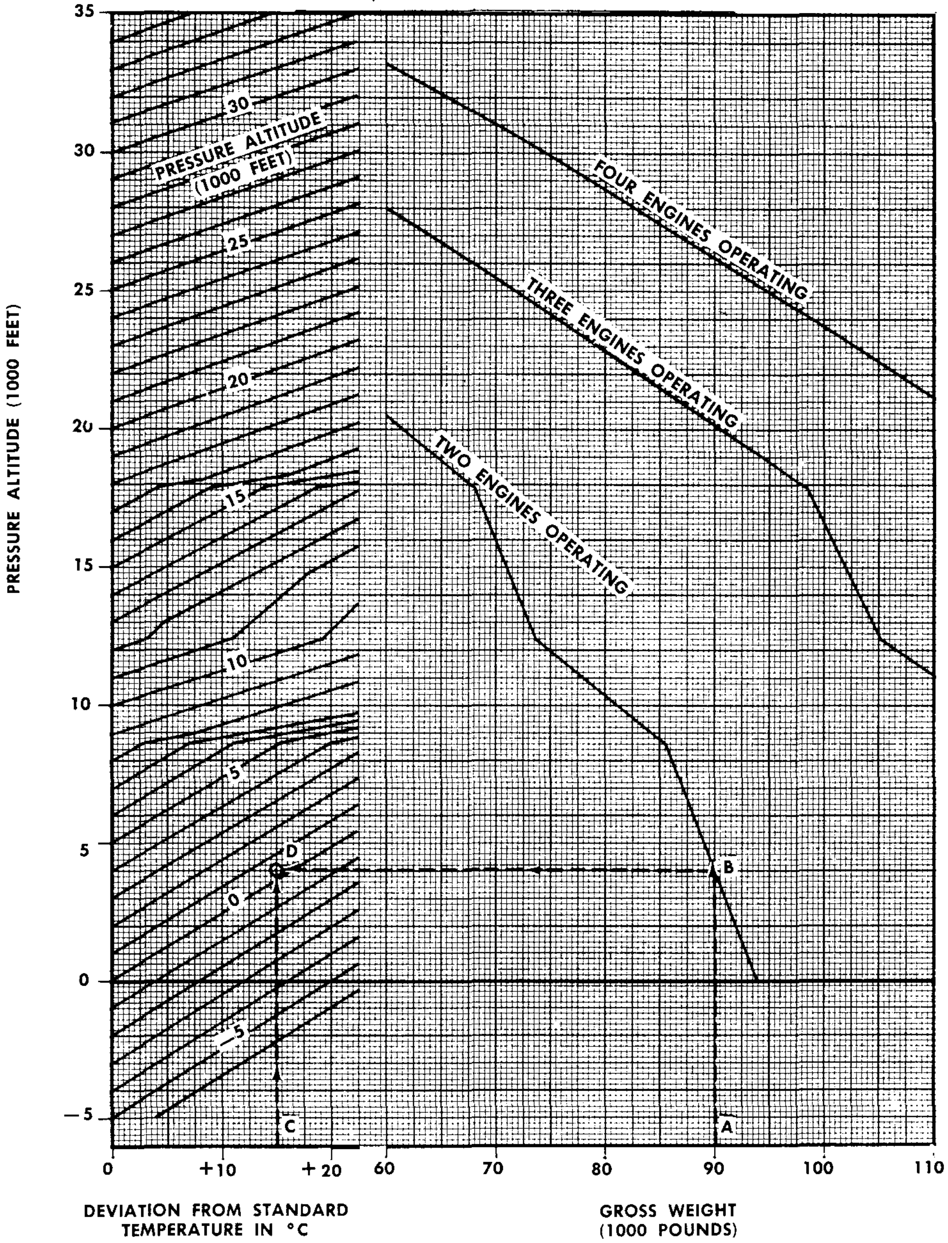


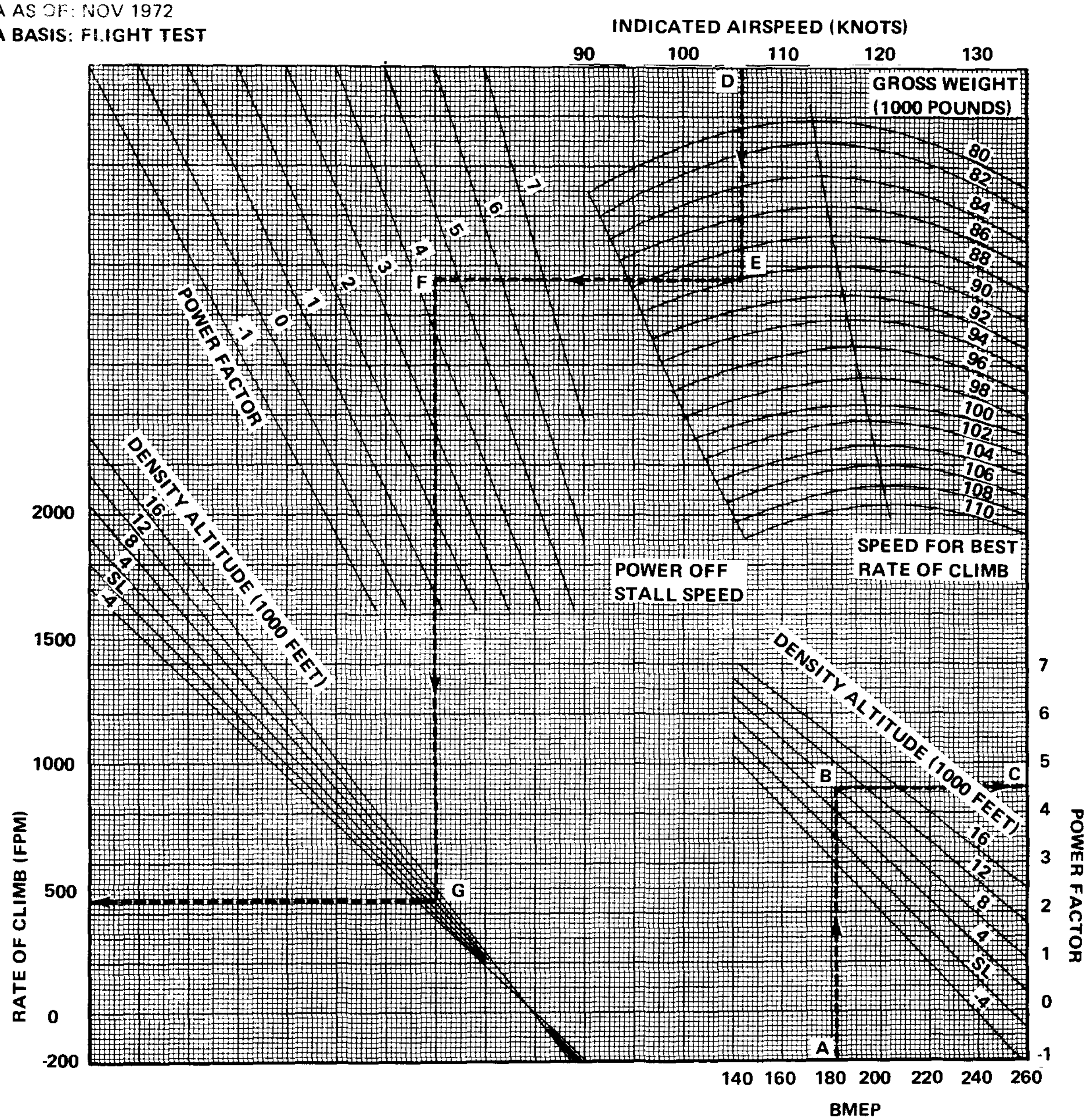
Figure A4-4. Emergency Ceiling - Alternate Fuel Grade

FOUR-ENGINE EMERGENCY CLIMB-TAKEOFF CONFIGURATION-FLAPS 20 DEGREES. GEAR DOWN

COWL FLAP SETTING: +3 DEGREES ON ALL ENGINES LOW BLOWER, 2800 RPM

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W



SAMPLE PROBLEM:

A. BMEP = 182 PSI.
B. DENSITY ALTITUDE = 8000 FEET.
C. POWER FACTOR = 4.5
D. INDICATED AIRSPEED = 106 KNOTS.
E. GROSS WEIGHT = 90,000 POUNDS.
F. POWER FACTOR = 4.5
G. DENSITY ALTITUDE = 8,000 FEET.
H. RATE OF CLIMB = 450 FPM.

NOTE:
Chart based on operation in low blower at 2800 RPM for operation in high blower at 2600 RPM, enter chart with equivalent BMEP. Equivalent BMEP = high blower BMEP x 0.93.

Figure A4-5. Four-Engine Emergency Climb - Takeoff Configuration - Flaps 20 Degrees, Gear Down

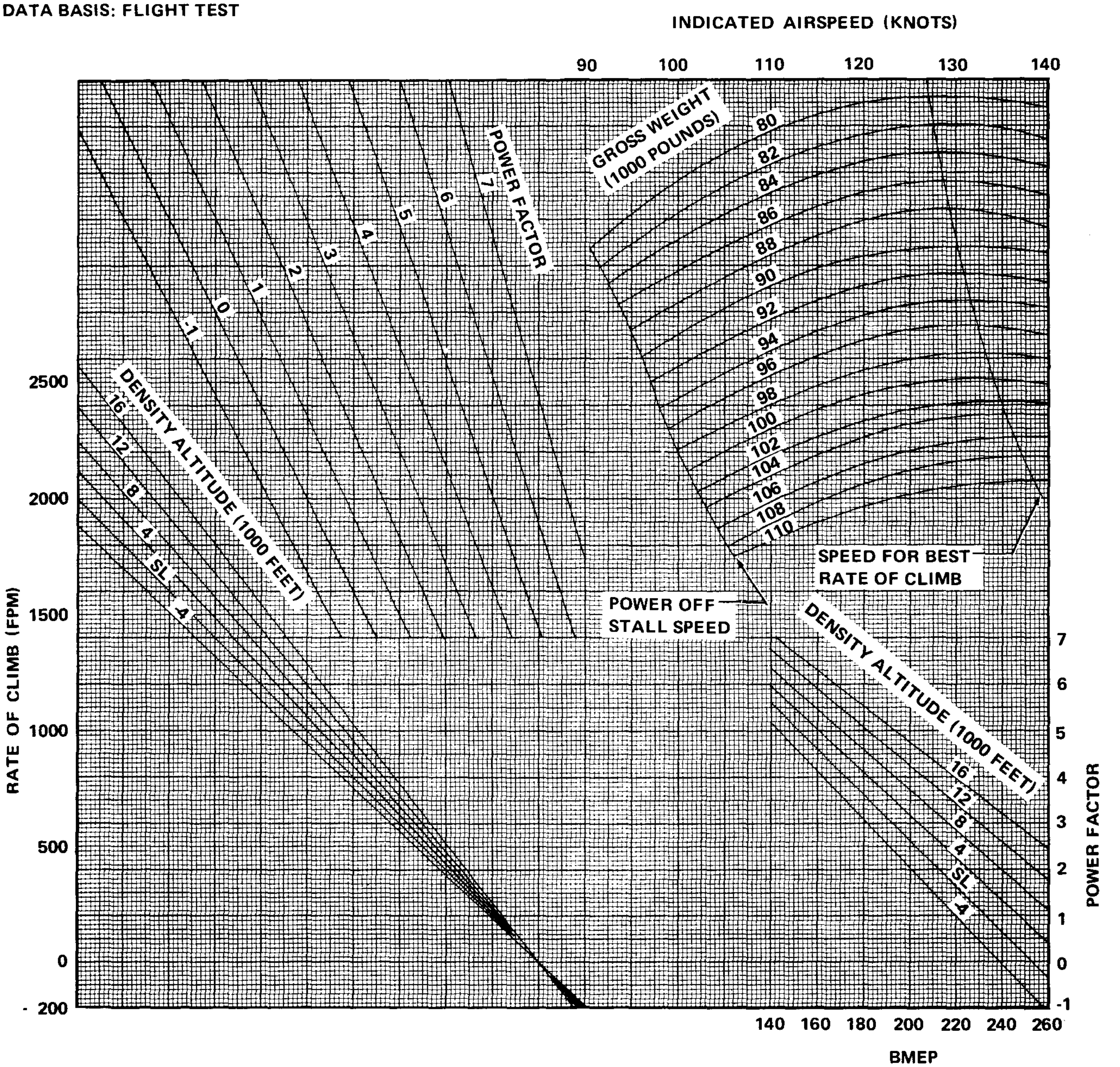
FOUR-ENGINE EMERGENCY CLIMB – TAKEOFF CONFIGURATION – FLAPS 20 DEGREES, GEAR UP

COWL FLAP SETTING: +3 DEGREES ON ALL ENGINES

LOW BLOWER, 2800 RPM

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W



NOTE:
Chart based on operation in low blower at 2800 RPM. For operation in high blower at 2600 RPM, enter chart with equivalent BMEP. Equivalent BMEP = High Blower x 0.93.

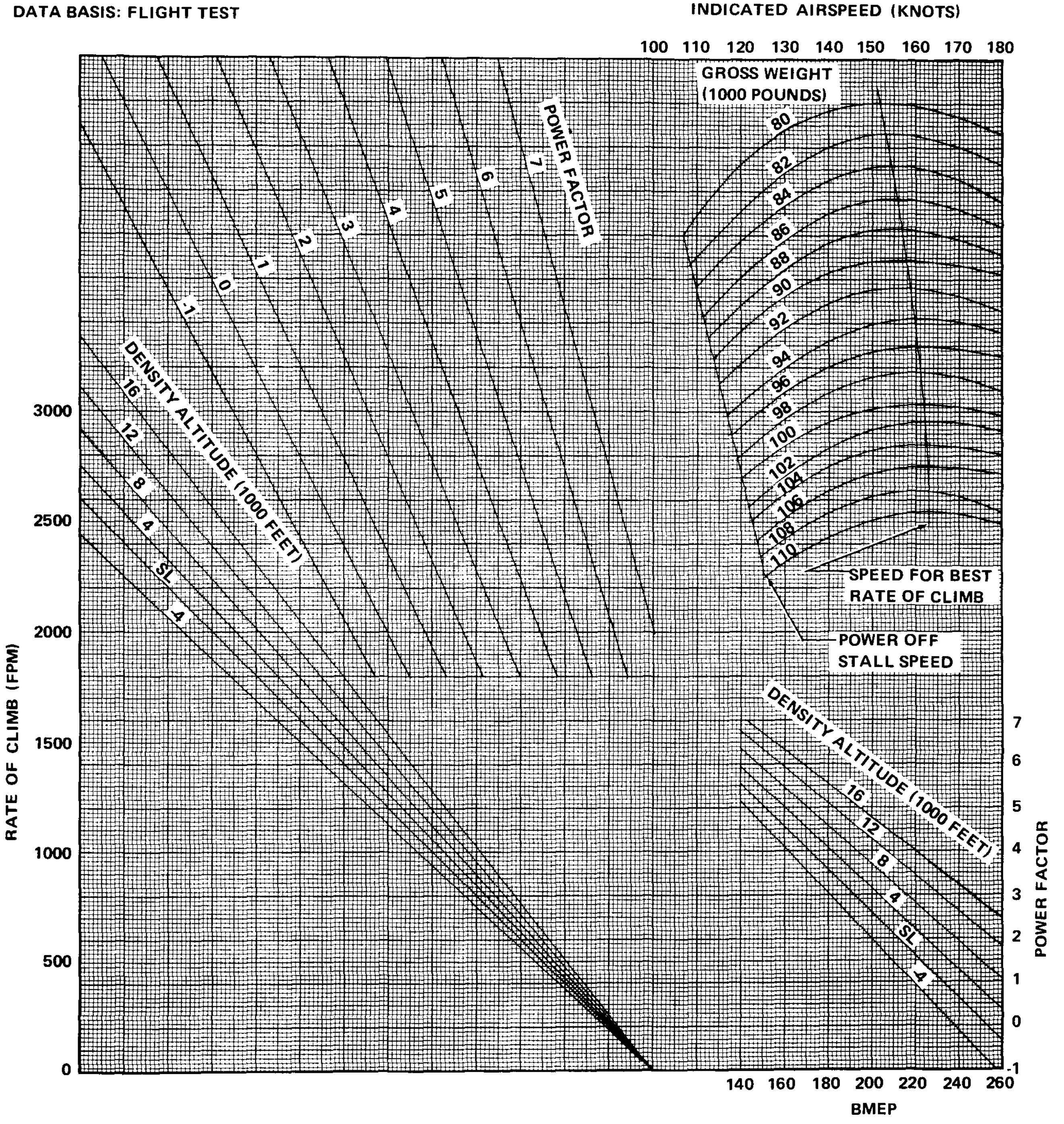
Figure A4-6. Four-Engine Emergency Climb - Takeoff Configuration - Flaps 20 Degrees, Gear Up

FOUR-ENGINE EMERGENCY CLIMB – ENROUTE CONFIGURATION – FLAPS UP, GEAR UP

COWL FLAP SETTING: +3 DEGREES ON ALL ENGINES
LOW BLOWER, 2800 RPM

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES (4) R2800-52W



NOTE:
Chart based on operation in low blower at 2800 RPM. For operation in high blower at 2600 RPM, enter chart with equivalent BMEP. Equivalent BMEP = High Blower BMEP x 0.93.

Figure A4-7. Four-Engine Emergency Climb - Enroute Configuration - Flaps Up, Gear Up

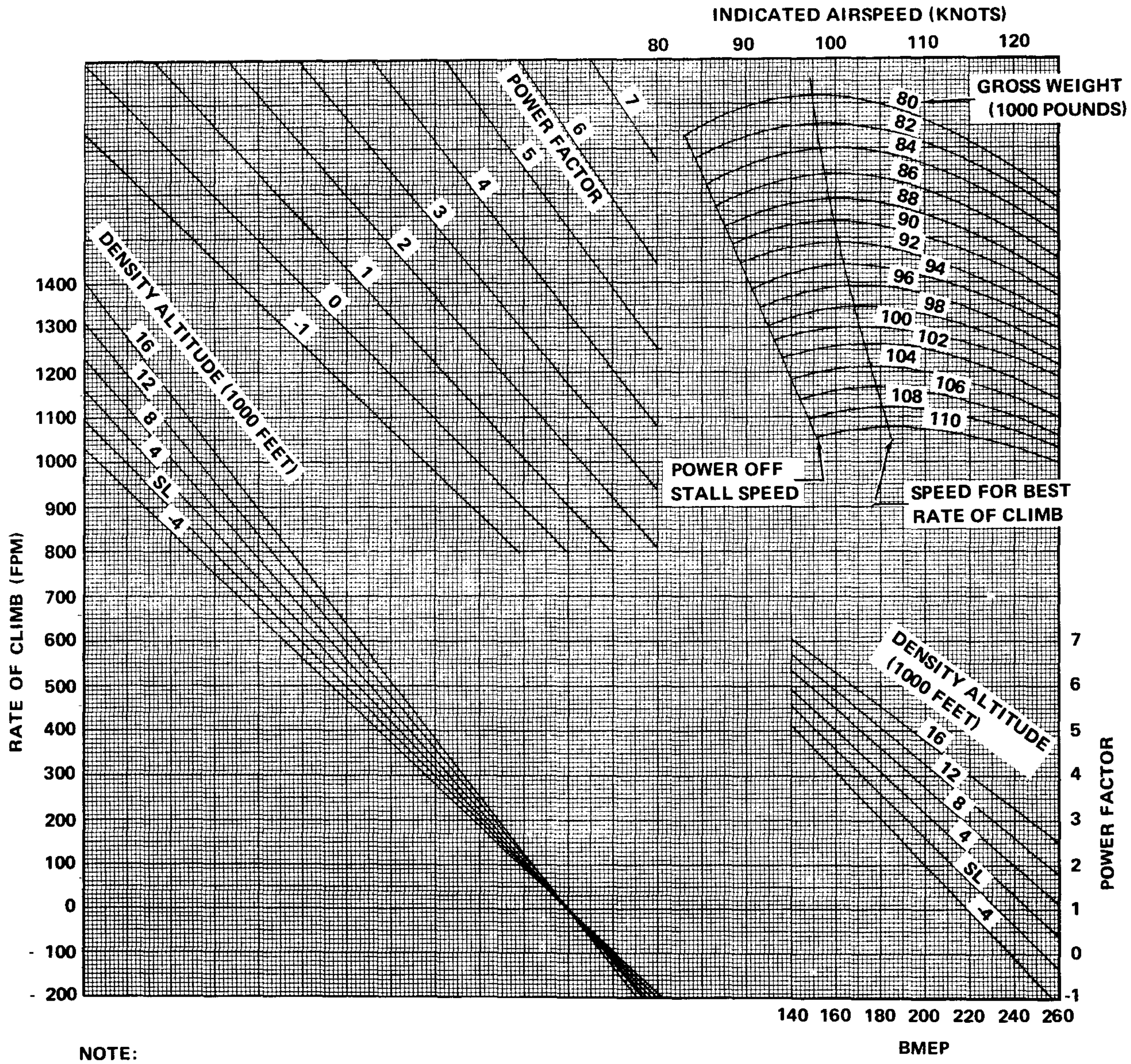
FOUR ENGINE EMERGENCY CLIMB – LANDING CONFIGURATION – FLAPS FULL DOWN, GEAR DOWN

COWL FLAP SETTING: +3 DEGREES ON ALL ENGINES

LOW BLOWER, 2800 RPM

MODEL: C-118A
DATA AS OF: NOV 72
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W



NOTE:
Chart based on operation in low blower at 2800 RPM. For operation in high blower at 2600 RPM, enter chart with equivalent BMEP. Equivalent BMEP = High Blower BMEP x .93.

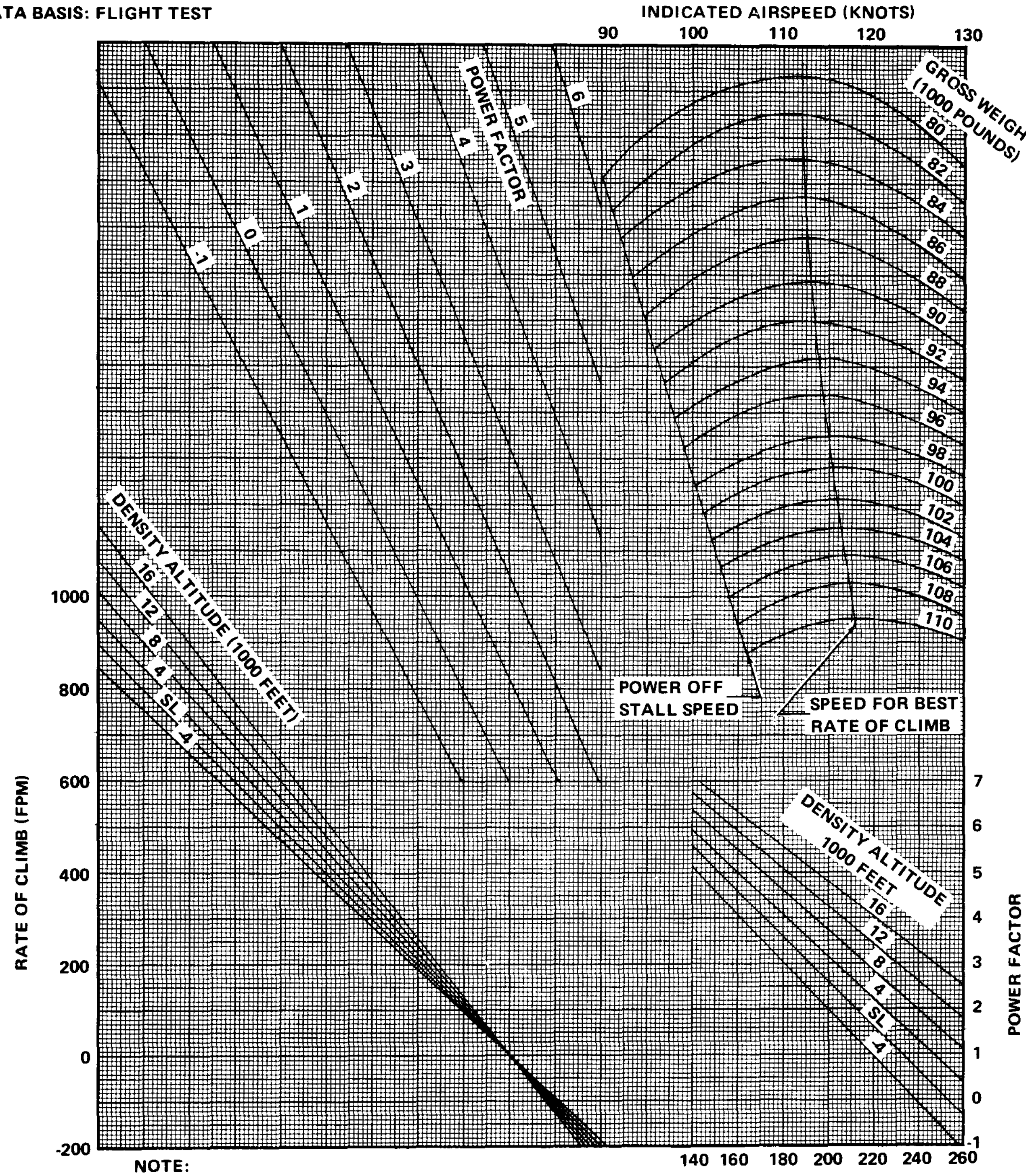
Figure A4-8. Four-Engine Emergency Climb - Landing Configuration - Flaps Full Down, Gear Down

THREE-ENGINE EMERGENCY CLIMB – TAKEOFF CONFIGURATION – FLAPS 20 DEGREES, GEAR DOWN

COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
-4 DEGREES ON INOPERATIVE ENGINE
PROPELLER FEATHERED ON INOPERATIVE ENGINE
LOWER BLOWER, 2800 RPM

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W



NOTE:
Chart based on operation in low blower at 2800 RPM. For operation in high blower at 2600 RPM, enter chart with equivalent BMEP. Equivalent BMEP = High Blower BMEP x .93.

Figure A4-9. Three-Engine Emergency Climb - Takeoff Configuration - Flaps 20 Degrees, Gear Down

THREE-ENGINE EMERGENCY CLIMB – TAKEOFF CONFIGURATION – FLAPS 20 DEGREES, GEAR UP

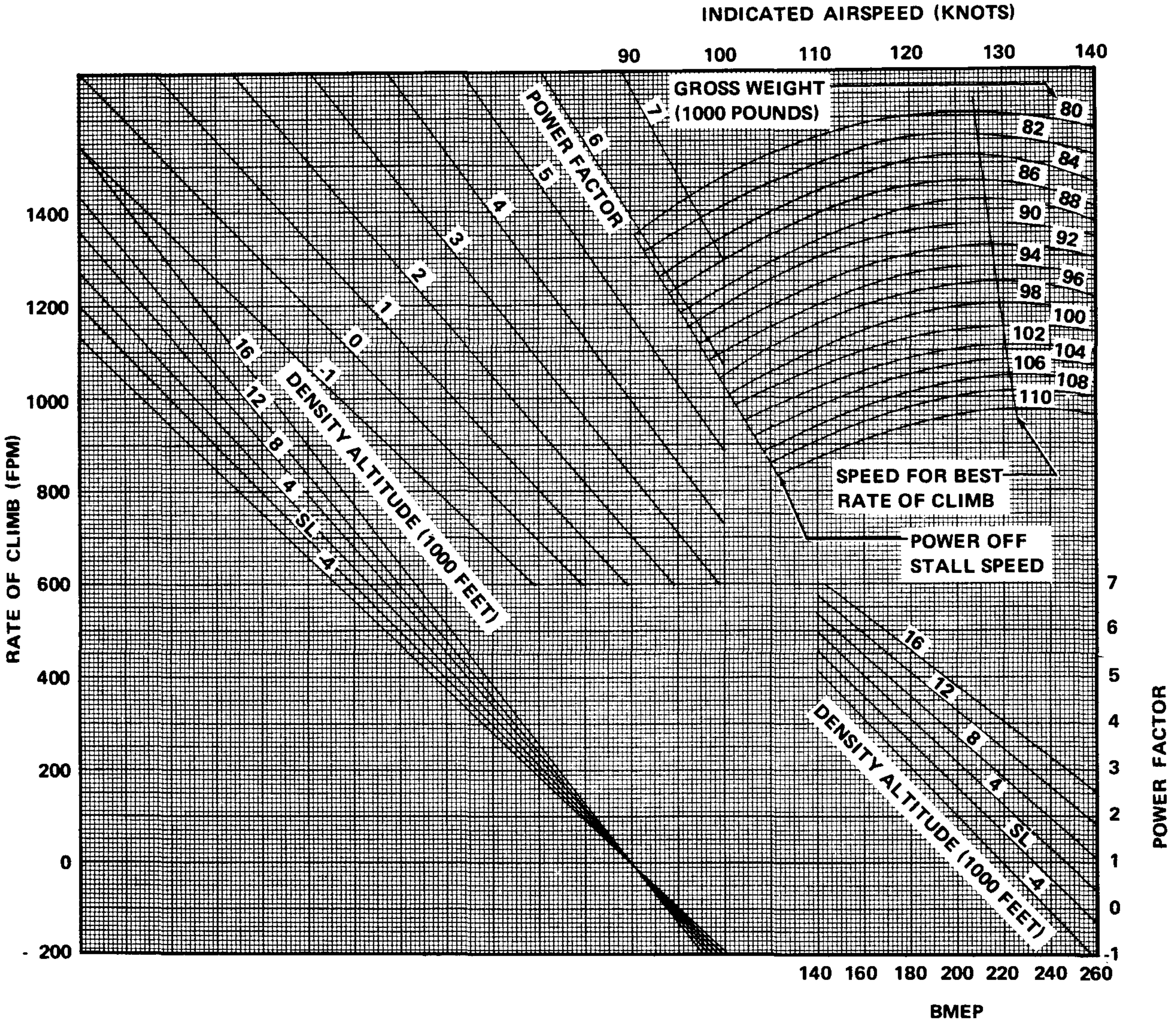
COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
-4 DEGREES ON INOPERATIVE ENGINES

PROPELLER FEATHERED ON INOPERATIVE ENGINE

LOW BLOWER, 2800 RPM

MODEL: C-118A
DATA AS OF: NOV 72
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W



NOTE:
Chart based on operation in low blower at 2800 RPM. For operation in high blower at 2600 RPM, enter chart with equivalent BMEP. Equivalent BMEP = High Blower BMEP x .93.

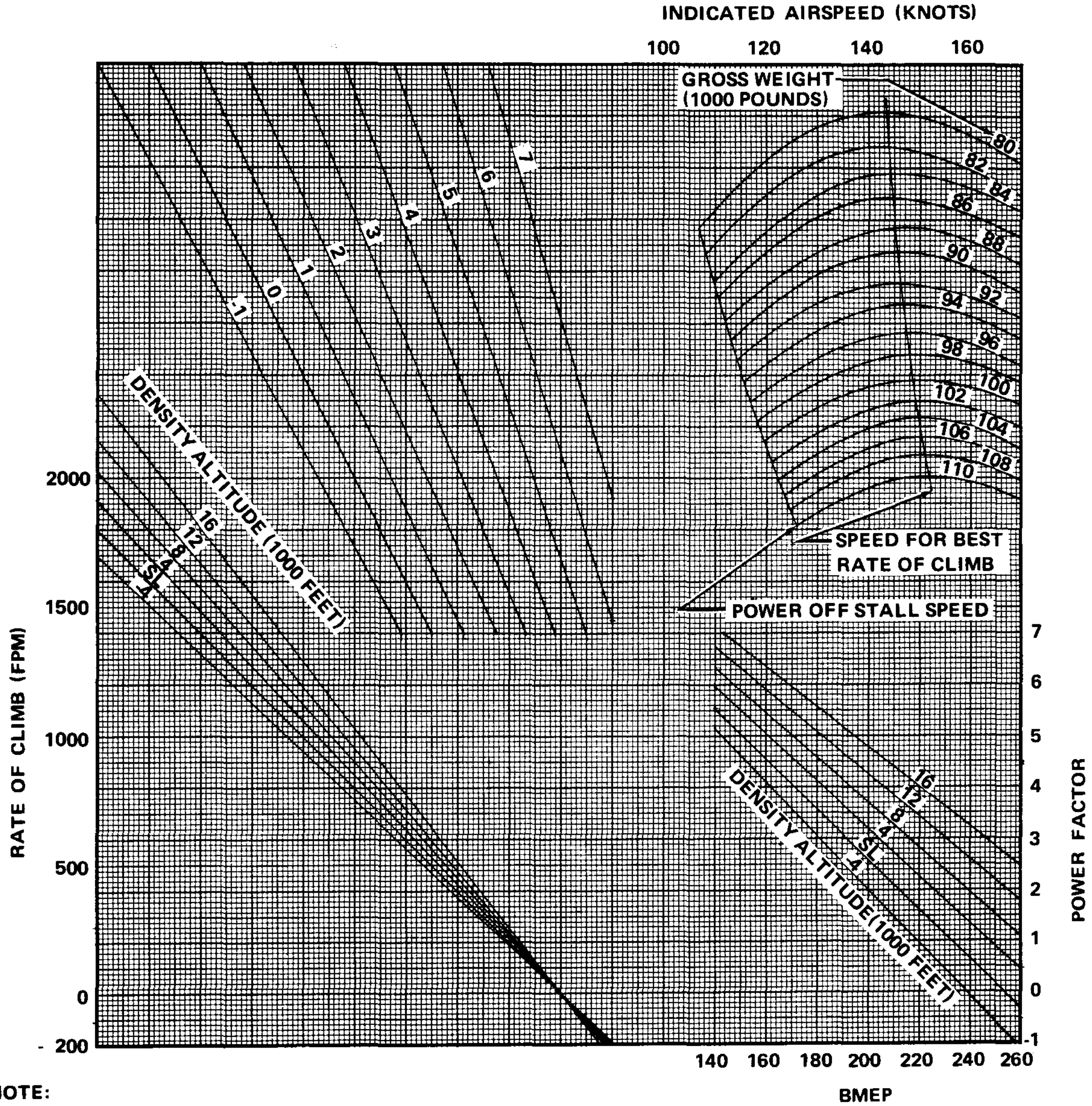
Figure A4-10. Three-Engine Emergency Climb - Takeoff Configuration - Flaps 20 Degrees, Gear Up

THREE-ENGINE EMERGENCY CLIMB – ENROUTE CONFIGURATION – FLAPS UP, GEAR UP

COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
-4 DEGREES ON INOPERATIVE ENGINE
PROPELLER FEATHERED ON INOPERATIVE ENGINE
LOW BLOWER, 2800 RPM

MODEL: C-118A
DATA AS OF: NOV 1972
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W



NOTE:
Chart based on operation in low blower at 2800 RPM. For operation in high blower at 2600 RPM, enter chart with equivalent BMEP. Equivalent BMEP = High Blower BMEP x .93.

Figure A4-11. Three-Engine Emergency Climb - Enroute Configuration - Flaps Up, Gear Up

THREE-ENGINE EMERGENCY CLIMB – LANDING CONFIGURATION – FLAPS FULL DOWN, GEAR DOWN

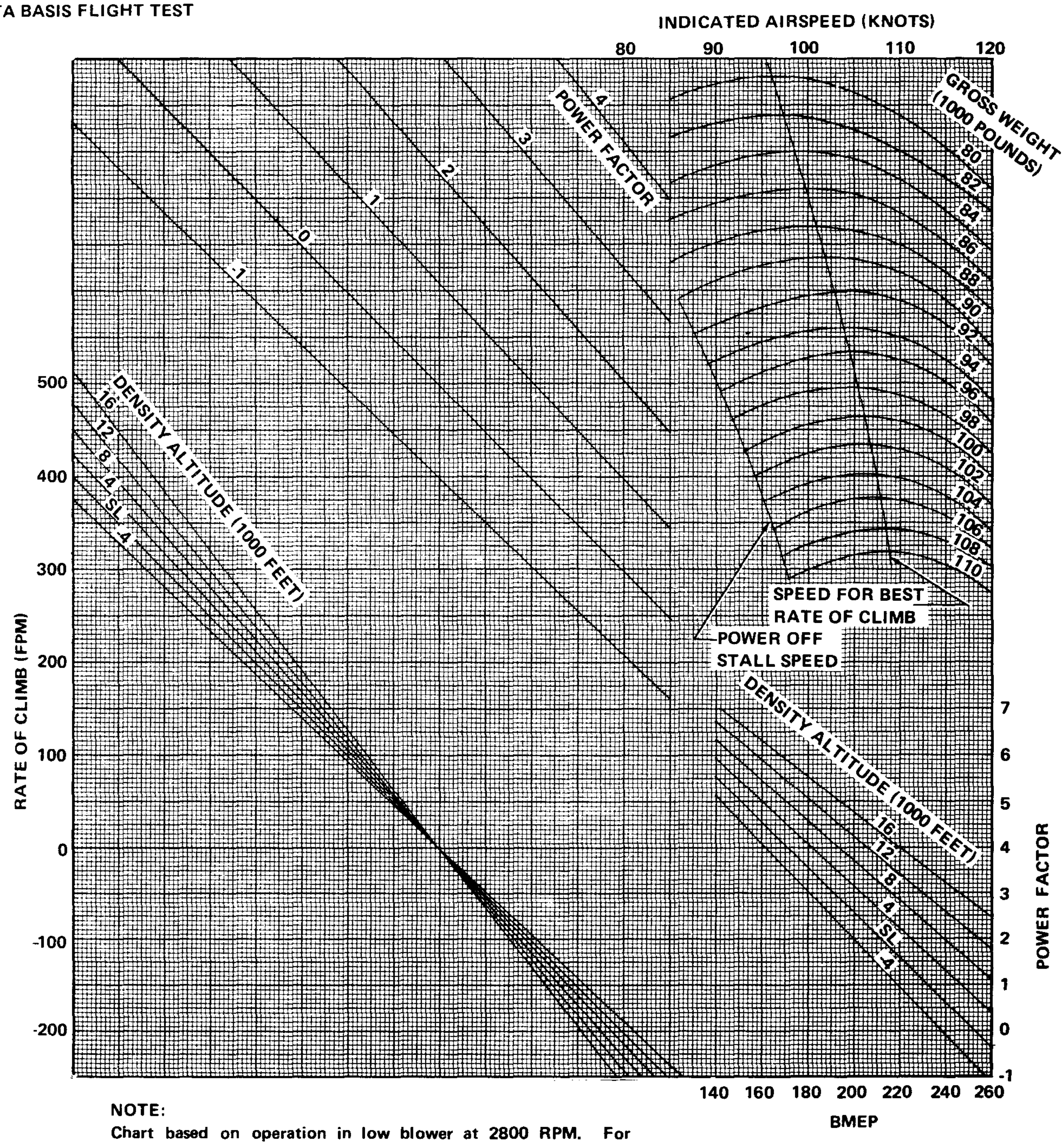
COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
-4 DEGREES ON INOPERATIVE ENGINES

PROPELLER FEATHERED ON INOPERATIVE ENGINE

LOW BLOWER, 2800 RPM

MODEL: C-118A
DATA AS OF: NOV 72
DATA BASIS FLIGHT TEST

ENGINES: (4) R2800-52W



NOTE:
Chart based on operation in low blower at 2800 RPM. For operation in high blower at 2600 RPM, enter chart with equivalent BMEP. Equivalent BMEP = High Blower BMEP x .93.

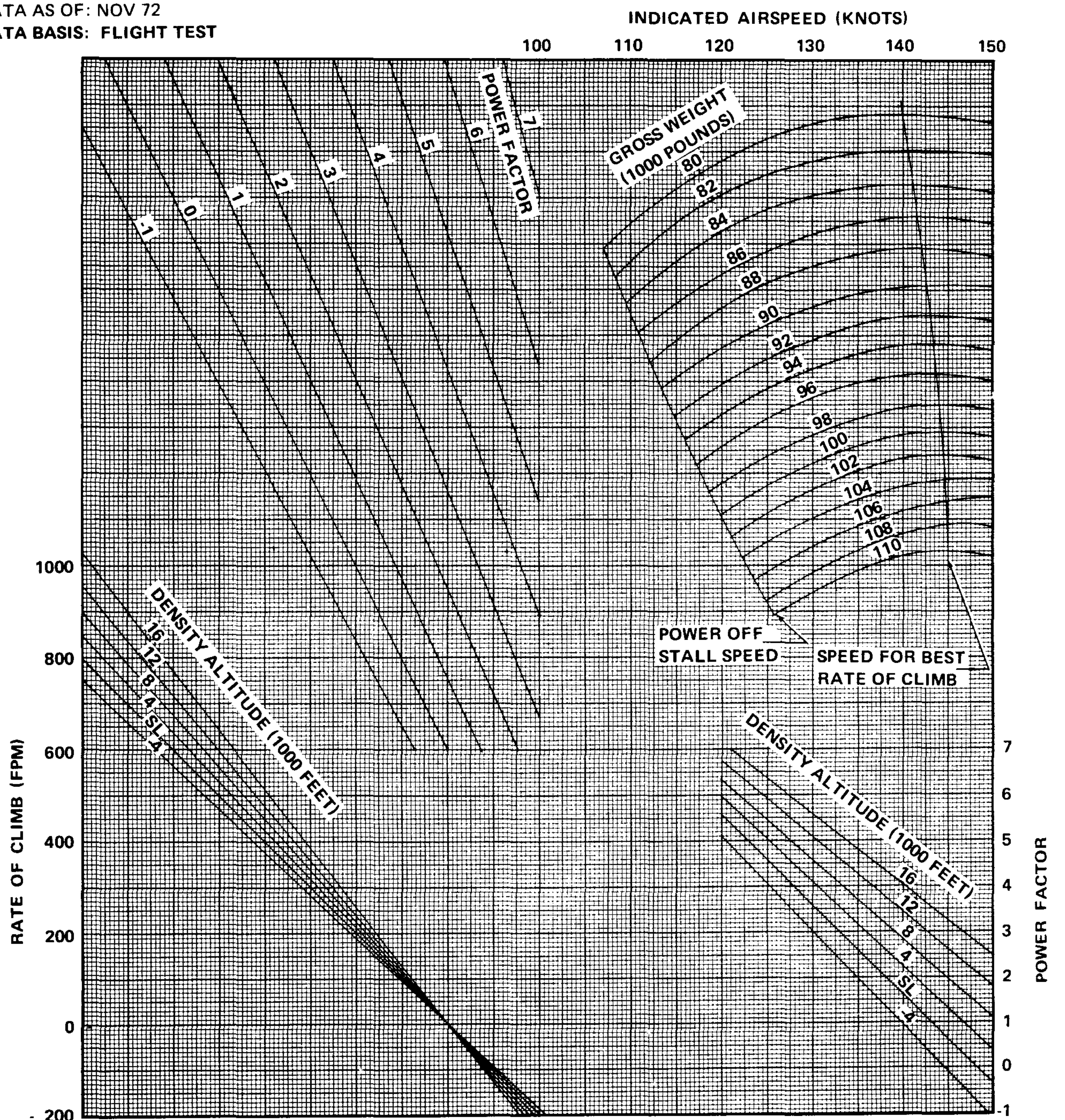
Figure A4-12. Three-Engine Emergency Climb - Landing Configuration - Flaps Full Down, Gear Down

TWO-ENGINE EMERGENCY CLIMB – ENROUTE CONFIGURATION – FLAPS UP, GEAR UP

COWL FLAP SETTING: +3 DEGREES ON OPERATING ENGINES
+4 DEGREES ON INOPERATIVE ENGINES
PROPELLERS FEATHERED ON INOPERATIVE ENGINES
LOW BLOWER, 2800 RPM

MODEL: C-118A
DATA AS OF: NOV 72
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W



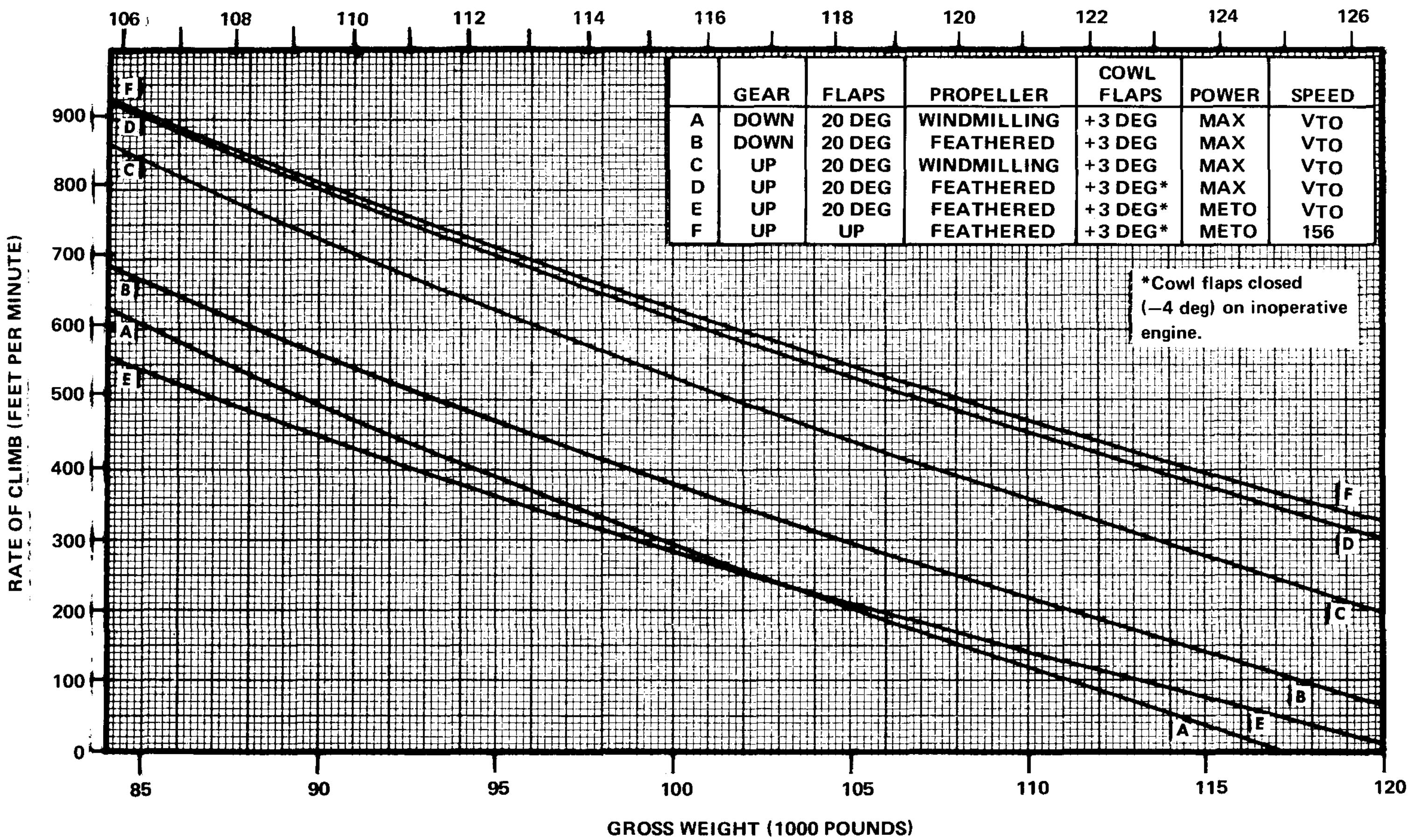
NOTE:
Chart based on operation in low blower at 2800 RPM. For operation in high blower at 2600 RPM, enter chart with equivalent BMEP. Equivalent BMEP = High Blower BMEP x .93.

Figure A4-13. Two-Engine Emergency Climb - Enroute Configuration - Flaps Up, Gear Up

THREE-ENGINE PERFORMANCE CLIMBS
SEA LEVEL
STANDARD ATMOSPHERIC CONDITIONS

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINE(S): (4) R2800-52W
WITH W/A INJECTION



	GEAR	FLAPS	PROPELLER	COWL FLAPS	POWER	SPEED
A	DOWN	20 DEG	WINDMILLING	+3 DEG	MAX	VTO
B	DOWN	20 DEG	FEATHERED	+3 DEG	MAX	VTO
C	UP	20 DEG	WINDMILLING	+3 DEG	MAX	VTO
D	UP	20 DEG	FEATHERED	+3 DEG*	MAX	VTO
E	UP	20 DEG	FEATHERED	+3 DEG*	METO	VTO
F	UP	UP	FEATHERED	+3 DEG*	METO	156

Figure A4-14. Three-Engine Performance Climbs

MODEL: C-118A
DATA AS OF: 12-15-66
DATA BASIS: ENGINE MANUFACTURER'S DATA

POWER SETTINGS FOR CLIMB
1400 BHP/ENGINE
150 TO 160 KIAS
200° CHT OR LESS DESIRED
AUTO RICH OPERATION

R2800-52W ENGINES
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

Pressure Altitude (Feet)	*Manifold Pressure at Carburetor Air Temperature °C (In. Hg)*							*RPM * and Blower*	*Minimum Fuel Flow Per Eng. (Lb./Hr.)*	*Nominal * BMEP (psi)*
	-30	-20	-10	0	+10	+20	+30			
18,000	38	*	*	*	*			2300 HIGH	920	172
16,000	37 1/2	38	39	40	40 1/4					
14,000	34 1/2	38	39	39 3/4	40 1/4					
12,000	34 3/4	35 1/2	36	36 1/2	37 1/2					
10,000	35	35 3/4	36 1/4	37	37 3/4	38 1/2	39	2300 LOW	896	172
8,000	35 1/4	36	36 1/2	37 1/4	38	38 1/2	39			
6,000	35 1/2	36 1/4	36 3/4	37 1/2	38	39	39 1/2			
4,000	35 3/4	36 1/2	37	37 3/4	38 1/2	39	40			
2,000	36	36 3/4	37 1/2	38	39	39 1/2	40			
S.L.	36 1/4	37	38	38 1/2	39	40	40 1/2			

* Above full throttle altitude increase RPM to maintain highest Map shown under appropriate CAT. For changes in RPM, fuel flow must be increased as shown on Figure A2-15, and BMEP must be decreased 7 BMEP per 100 RPM. Do not exceed 2600 RPM.

Figure A4-15. Power Settings for Climb at 1400 BHP/Engine

POWER SETTINGS FOR CLIMB
1500 BHP/ENGINE
150 TO 160 KIAS
AUTO RICH OPERATION

MODEL: C-118A
DATA AS OF: 12-15-66
DATA BASIS: ENGINE MANUFACTURER'S DATA

R2800-52W ENGINES
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

Pressure Altitude (Feet)	*Manifold Pressure at Carburetor Air Temperature °C (In. Hg)*							*RPM * and Blower*	*Minimum Fuel Flow Per Eng. (Lb./Hr.)*	*Nominal * BMEP (psi)*
	-30	-20	-10	0	+10	+20	+30			
18,000	40	*	*	*	*					
16,000	40	40 3/4	41 1/2	42 1/4	43	*	*	2400 HIGH	1070	177
14,000	36 1/4	40 3/4	41 1/2	42 1/4	43	43 3/4				
12,000	36 1/2	37 1/4	38	38 3/4	43	43 3/4				
10,000	36 3/4	37 1/2	38 1/4	39	39 3/4	40 1/2	41			
8,000	37	37 3/4	38 1/2	39 1/4	40	40 3/4	41 1/4			
6,000	37 1/4	38	38 3/4	39 1/2	40 1/4	41	41 1/2	2400 LOW	1015	177
4,000	37 1/2	38 1/2	39	39 3/4	40 1/2	41 1/4	41 3/4			
2,000	38	38 3/4	39 1/4	40	40 3/4	41 1/2	42 1/4			
S.L.	38 1/2	39 1/4	39 3/4	40 1/2	41 1/4	42	42 3/4			

* Above full throttle altitude increase RPM to maintain highest Map shown under appropriate CAT. For changes in RPM, fuel flow must be increased as shown on Figure A2-15, and BMEP must be decreased 7 BMEP per 100 RPM. Do not exceed 2600 RPM.

AA1-589

Figure A4-16. Power Settings for Climb at 1500 BHP/Engine

MODEL: C-118A
DATA AS OF: 12-15-66
DATA BASIS: ENGINE MANUFACTURER'S DATA

POWER SETTINGS FOR CLIMB
1600 BHP/ENGINE
THREE AND TWO-ENGINE OPERATION
150 TO 160 KIAS
AUTO RICH OPERATION

R2800-52W ENGINES
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

Pressure Altitude (Feet)	*Manifold Pressure at Carburetor Air Temperature °C (In. Hg)*							*RPM* * *and Blower*	*Minimum Fuel Flow Per Eng. (Lb./Hr.)*	*Nominal* * *BMEP (psi)*
	-30	-20	-10	0	+10	+20	+30			
18,000	43	*	*	*	*					
16,000	43	43 3/4	44 1/2	45 1/4	46	*		2500 HIGH	1240	181
14,000	38 1/2	43 3/4	44 1/2	45 1/4	46	46 3/4				
12,000	38 3/4	39 1/2	40 1/4	41	46	46 3/4				
10,000	39	39 3/4	40 1/2	41 1/4	42	42 3/4	43 1/4			
8,000	39 1/4	40	40 3/4	41 1/2	42 1/4	43	43 1/2			
6,000	39 1/2	40 1/4	41	41 3/4	42 1/2	43 1/4	43 3/4	2500 LOW	1140	181
4,000	39 3/4	40 3/4	41 1/4	42	42 3/4	43 1/2	44 1/4			
2,000	40 1/4	41	41 3/4	42 1/2	43 1/4	44	44 3/4			
S.L.	40 3/4	41 1/2	42 1/4	43	43 3/4	44 1/2	45 1/4			

* Above full throttle altitude increase RPM to maintain highest Map shown under appropriate CAT. For changes in RPM, fuel flow must be increased as shown on Figure A2-15, and BMEP must be decreased 7 BMEP per 100 RPM. Do not exceed 2600 RPM.

Figure A4-17. Power Settings for Climb at 1600 BHP/Engine

AA1-590

MODEL: C-118A
DATA AS OF: 12-15-66
DATA BASIS: ENGINE MANUFACTURER'S DATA

POWER SETTINGS FOR CLIMB
1700 BHP/ENGINE
THREE AND TWO-ENGINE OPERATION
150 TO 160 KIAS
AUTO RICH OPERATION

R2800-52W ENGINES
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

Pressure Altitude (Feet)	*Manifold Pressure at Carburetor Air Temperature °C (In. Hg)*							*RPM and Blower*	*Minimum Fuel Flow Per Eng. (Lb./Hr.)*	*Nominal BMEP (psi)*
	-30	-20	-10	0	+10	+20	+30			
18,000										
16,000	46 1/4	47						2600 HIGH	1360	185
14,000	46 1/4	47	47 3/4	48 1/2						
12,000	41 1/4	47	47 3/4	48 1/2	49 1/4	50				
10,000	41 1/2	42 1/2	43 1/4	44	49 1/2	50 1/4				
8,000	41 3/4	42 3/4	43 1/2	44 1/4	45	45 3/4	46 1/4			
6,000	42	43 1/4	43 3/4	44 1/2	45 1/4	46	46 1/2	2500 LOW	1240	192
4,000	42 1/2	43 1/2	44	44 3/4	45 1/2	46 1/4	47			
2,000	43	43 3/4	44 1/2	45 1/4	46	46 3/4	47 1/2			
S.L.	43 1/2	44 1/4	45	45 3/4	46 1/2	47 1/4	48			

Figure A4-18. Power Settings for Climb at 1700 BHP/Engine

METO POWER SCHEDULE
AUTO RICH OPERATION

MODEL: C-118A
DATA AS OF: 7-17-57
DATA BASIS: ENGINE MANUFACTURES DATA

R2800-52W ENGINES
FUEL GRADE: 115/145

Pressure Altitude (Feet)	*Manifold Pressure at Carburetor Air Temperature °C (In. Hg)*							*RPM and Blower*	*BHP*	*Minimum Fuel Flow Per Eng. (Lb./Hr.)*	*Nominal BMEP (psi)*
	- 30	- 20	- 10	0	+ 10	+ 20	+ 30				
18,000	43.6										
16,000	46.2	44.7	45.6								
14,000	46.6	47.6	48.5	46.7	47.5	48.4		2600 High	1600	1300	185
12,000	43.2	48.1	49.0	49.9	50.8	48.7					
10,000	43.2	44.0	44.8	50.4	51.3	52.3		2600 High	1700	1360	185
8,000	47.1	48.0	44.8	45.6	46.4	47.1					
6,000	47.1	48.1	49.0	49.9	50.9	47.2	47.9	2600 Low	1700	1260	207
4,000	47.2	48.1	49.1	50.0	50.9	51.5		2600 Low	1900	1460	207
2,000	47.2	48.2	49.2	50.1	51.0	51.5					
S.L.	47.3	48.3	49.2	50.1	51.0	51.5					

Figure A4-19. METO Power Schedule - Auto Rich Operation

part 5
cruise

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

INTRODUCTION.

The information provided in this part is for cruising in level flight. The charts are based on standard atmospheric conditions. However, they are applicable to nonstandard conditions at the same density altitude if allowance is made for the change in cowl flap setting required to maintain proper engine cooling. The cruise charts for four engines operating are based on a cowl flap setting of -2 degrees. When predicting BHP required for cruise, consideration should be given to the additional BHP required for cowl flap setting in excess of -2 degrees. For each degree that the cowl flaps are opened beyond -2 degrees, the aircraft will lose approximately 3 KEAS. Or, if the power is increased to maintain a constant speed, each degree that the cowl flaps are opened beyond -2 degrees will require approximately 15 additional brake horsepower per engine at sea level. To obtain true brake horsepower at altitude, multiply the sea level brake horsepower by $1/\sqrt{\sigma}$.

TYPES OF CRUISE.

Optimum performance for varying mission requirements calls for selection of the type of cruise best suited for a particular mission. The five types of cruise that may be used are constant power, constant speed, maximum range, long range, and maximum endurance. Each has certain advantages for different type of missions, and disadvantages which make the use of each type of cruise impractical under certain conditions. The underlying factor for any type of cruise is economy of operation. Proper understanding of the different types of cruise and the interpretation of the cruise performance charts will enable the crew to determine the best type of cruise for a particular mission.

CONSTANT POWER CRUISE.

Constant power cruise is the simplest cruise technique, and consists of establishing a power and flying the mission, or a part of the mission, at that power. It has the advantage on relatively short missions of eliminating the necessity for constant changes of power. In case of an inflight emergency, where speed is of primary importance, it could be used by selecting the highest power that could be maintained and still reach the destination with the amount of fuel available.

Disadvantages are, when used over a period of several hours, fuel consumption is high, and spark plugs have a tendency to foul more readily when the same power setting is used for prolonged periods of time than when frequent power changes are made. Constant power cruise should be employed only when high speed is required rather than economy.

CONSTANT SPEED CRUISE.

Constant speed cruise is accomplished by periodic reduction of power as gross weight is reduced to maintain a constant airspeed. This type of cruise is normally used when it is necessary to maintain a schedule or to rendezvous at a given point at a specified time. Fuel economy will vary sharply with the speed that is chosen. For short missions, an airspeed can be used which will yield a range very close to maximum or long range cruise. However, for longer missions, an airspeed low enough to provide a fair degree of economy will cause difficulty in control of the aircraft at the high gross weights at beginning of cruise, thus contributing to crew fatigue on long missions. Selection of an airspeed high enough to give good handling characteristics during the first portion of the mission will result in higher than necessary fuel consumption at the end of the mission.

MAXIMUM RANGE CRUISE.

Maximum range cruise provides the maximum fuel economy, or the greatest range that can be obtained from a given amount of fuel. For this method of cruise, the aircraft is flown at a speed which results in an angle of attack given the best L/D ratio. Since L/D is a function of gross weight and airspeed, it is necessary to reduce airspeed as gross weight is reduced to maintain the angle of attack for the least drag. The power required to maintain the airspeed for best L/D ratio is selected to provide the best compromise between specific fuel consumption and propeller efficiency, which also vary with airspeed and altitude. The airspeed for maximum range, and the power required to maintain this airspeed are found at the peak of each gross weight curve on the Nautical Miles Per Pound Of Fuel charts.

In addition to the variables already considered, range is also affected by altitude. This can be found by comparing range data on the Nautical Miles Per Pound Of Fuel charts for the same conditions at different altitudes. Generally, best economy is obtained at low altitudes with a high gross weight, and at high altitudes with low gross weights. For this reason, maximum range is usually obtained by remaining at a low altitude until fuel is burned off and then climbing to higher cruise altitude.

LONG RANGE CRUISE.

Long range cruise procedures are the same as for maximum range, with power being reduced periodically to maintain the desired cruise airspeed as gross weight is reduced. For this type of cruise, an airspeed is selected which is approximately 110 percent of the speed for maximum range cruise. The resulting airspeed will give better handling characteristics and shorter flight times, with only a slight loss in range. Generally, for a loss of 1 percent in range, an increase in speed of approximately 4 1/2 percent will be realized. As with maximum range cruise, the disadvantage is that gross weight must be computed as fuel is burned off, and adjustments made in power settings and airspeed.

MAXIMUM ENDURANCE CRUISE.

Maximum Endurance cruise requires the lowest possible rate of fuel consumption to provide the maximum time in the air for a given amount of fuel. This type of cruise is normally used only when the primary objective is to remain airborne for extended periods of time, such as holding over destination during adverse weather conditions. As with maximum range and long range cruise, power settings and airspeed are reduced as gross weight is reduced. In this type of cruise however, since distance is of little concern, an airspeed is chosen by its relationship to power required to maintain level flight. Airspeeds for maximum endurance are lower than for other types of cruise, and range is reduced considerably over that obtained at maximum or long range cruise. Due to lower power requirements, maximum endurance is best obtained at lower altitudes. Spark plugs have a tendency to foul when the same power settings are used for prolonged periods of time.

LONG RANGE OPERATION.

The amount of range that may be obtained from a given amount of fuel will vary considerably, depending on the cruise technique used. Unless high speed is the primary consideration, it is generally desirable to cruise in such a manner that maximum range may be obtained from a given amount of fuel (or a minimum of fuel will be required to fly a given distance), without increasing cruise time more than necessary. In doing this there are two techniques that must be used. The first is to set engine powers so that a minimum fuel flow results from a given brake horsepower. The second technique is to cruise at the speed which results in the most miles per pound of fuel.

In setting up engine powers for minimum fuel flow, the first step is to use the lowest RPM allowable for a given brake horsepower. This minimum RPM may be obtained from the Power Settings for Cruise Tables (the even numbered figures from A5-36 through A5-60) or from the BHP-RPM Schedules (figures **A2-18** and **A2-20**). The power setting tables show only the even 100 RPM's, while the BHP-RPM Schedules show a continuous variation of RPM. The second step is to adjust the mixture to obtain the minimum fuel flow for a given brake horsepower. The fuel flow curves on the Estimated Fuel Consumption for Cruise Power charts (figures **A2-16** and **A2-17**) indicate the fuel flows which will result in best economy mixture settings. However, it is difficult to obtain best economy mixture settings and any error on the lean side may result in unstable operation. In addition, operation at lean mixture settings is restricted to brake horsepowers of 1240 BHP or less in low blower and 1200 BHP or less in high blower. Manual lean mixture settings using a 12 BMEP drop from best power mixture, or manual rich mixture settings are used, depending on the requirements of the cruise performance charts. A description of the method used in settings cruise mixtures for both 12 BMEP drop and manual rich is included in Part 2.

On the Nautical Miles per Pound of Fuel Charts (figures A5-1 through A5-20) the highest point on any gross weight curve shows the speed (and brake horsepower) for obtaining the maximum range per pound of fuel. Generally, however, to obtain better handling characteristics, and to obtain a substantial increase in speed for only a slight loss in miles per pound of fuel, aircraft are flown at a higher speed which still results in 99 percent of the maximum miles per pound of fuel. For the C-118A this speed for 99 percent of maximum range is very near to 110 percent of the speed for maximum ratio of lift to drag (110 percent of $V_{L/D}$). For this reason 110 percent of $V_{L/D}$ is also referred to as long range cruise speed. This speed varies with gross weight and is shown on the Nautical Miles per Pound of Fuel Charts (figures A5-1 through A5-20), Long Range Summary Charts (figures A5-21 through A5-23) and the Level Flight Performance Charts (figures A5-27 and A5-28). As fuel is consumed the gross weight decreases and, hence, the power required and the speed for long range cruise both decrease also. If the power is not adjusted periodically the aircraft will increase in speed as the gross weight decreases. For this reason it is recommended that at least once an hour the gross weight be computed and the power reduced to the appropriate value.

DISCUSSION OF CHARTS.

NOTE

The fuel flow values used as a basis for the Nautical Miles Per Pound Of Fuel, the Long Range Summary, the Maximum Endurance Conditions, and the Range Prediction charts are based on approximately AUTO LEAN mixture settings. When the Estimated Fuel Consumption For Cruise, and the Power Settings For Cruise charts, based on the 12 or 2 BMEP drop method of setting power are employed, better fuel economy will be realized. The MANUAL LEAN callouts identify the BHPs for which manual lean settings may be used.

NAUTICAL MILES PER POUND OF FUEL CHARTS.

The Nautical Miles per Pound of Fuel Charts (figures A5-1 through A5-20) indicate the nautical miles that can be traveled for each pound of fuel consumed and the airspeeds that can be expected for various altitudes, gross weights and brake horsepowers. Both calibrated airspeed and true airspeed can be read.

Graphs are included at 1000-foot intervals for four-engine operation, and at 5000-foot intervals for three-engine and two-engine operation.

Each graph consists of a set of curves for constant gross weights intersected by a set of straight lines for constant values of brake horsepower per engine. Any given combination of gross weight and brake horsepower determines a point on the graph. From this point one projects horizontally to the left to read nautical miles per pound of fuel and vertically downward to read calibrated and true airspeeds.

In addition, two curves are shown on each graph to indicate values for long range operation. One of these curves is identified as "Recommended Long Range Cruise Speed (110 percent of $V_{L/D}$)" and the other as "110 percent of the Speed for Maximum Range."

The recommended long range cruise speed curve (110 percent of $V_{L/D}$) provides a type of operation which is practical for long flights. Furthermore, the recommended long range cruise speed is in the vicinity of the speed for maximum miles per pound (which would be drawn through the peaks of the gross weight curves), and has the advantage of being generally on the fast side of this speed. The result is to reduce the flight time as compared to that for maximum miles per pound at only a very slight sacrifice in range. It is therefore recommended that long range flights be conducted at "Recommended Long Range Cruise Speed (110 percent of $V_{L/D}$)." It may be noted that operation at 110 percent of $V_{L/D}$ results in maintaining a constant angle of attack throughout the flight.

The 110 percent of speed for Maximum Range curve provides a type of operation which is practical when operating with headwinds over 50 knots. The speeds obtained by the use of this curve result in a decreased mission time, thereby offsetting the increased fuel flow required. It must be remembered, however, that use of this curve is recommended only when operating under headwind conditions.

In this appendix, the Long Range Summary Graphs (figures A5-21 through A5-23) and the Range Prediction Charts (figures A5-30 through A5-37) are based on operation at the "Recommended Long Range Cruise Speed (110 percent of $V_{L/D}$)." The brake horsepower required to fly at the recommended long range cruise speed is read (by interpolation if necessary) on each chart of nautical miles per pound of fuel. Since these charts are furnished only for altitudes in 1000-foot steps, the brake horsepower for four-engine operation at intermediate altitudes can be obtained from the Power Required to Maintain 1.1 $V_{L/D}$ Chart (figure A5-29).

It will be observed in the nautical miles per pound of fuel charts that both manual lean and manual rich mixture settings are used, depending upon the brake horsepower. The use of low blower or high blower is also indicated. In some charts a note should be observed requiring the use of 115/145 grade fuel when the brake horsepower exceeds specified values.

Sample Problem:

GIVEN: Cruise altitude = 20,000 feet density altitude.

Gross weight = 90,000 pounds.

Four engines operating.

FIND: Power required to cruise at long range cruise speed.

Nautical miles per pound of fuel.

1. Enter the chart (figure A5-13) at the intersection of 90,000 pounds and the curve labeled "Recommended Long Range Cruise Speed."

2. By interpolation, read the power required, 1075 BHP/engine, high blower, manual lean.

3. Go horizontally to the left-hand scale and read the nautical miles per pound of fuel, 0.1145.

4. From the point described in step A, drop straight down to the scale at the bottom of the chart and read the calibrated airspeed, 183 knots.

5. Continue down to the next scale and read the true airspeed, 248 knots.

LONG RANGE SUMMARY CHARTS.

These charts show the nautical miles per pound of fuel, fuel flow, calibrated airspeed, and engine settings for maintaining long range cruise speed with either four engines operating (figure A5-21), three engines operating (figure A5-22), or two engines operating (figure A5-23). For this aircraft, long range cruise speed is 110 percent of the speed for maximum lift to drag ratio (110 percent of $V_{L/D}$).

These charts are based on standard atmospheric conditions. However, the calibrated airspeed and BHP/engine will remain unchanged for nonstandard conditions at the same density altitude. The RPM and fuel flow will increase slightly as temperature increases, while the BMEP and nautical miles per pound of fuel will decrease slightly.

Sample Problem:

GIVEN: Engines operating = Four.

Cruise altitude = 15,000 feet.

Gross weight = 100,000 pounds.

FIND: CAS, BHP/Engine, RPM, BMEP, fuel flow for four-engine operation, and nautical miles per pound of fuel.

1. Enter the Four-Engine Long Range Summary chart (figure A5-21) at a gross weight of 100,000 pounds (A) and proceed vertically through the chart.

2. At the intersection of the 100,000-pound gross weight line and the 15,000-foot altitude curves, read across to the appropriate scale at the side of the chart to find: CAS of 193 knots (B), BHP/engine of 1160 (C), RPM 2150 (D), BMEP 153 (E), fuel flow of 2250 pounds per hour (F), and nautical miles per pound of fuel of 0.108 (G).

3. Since the gross weight line intersects the altitude curve in the solid portion of the curves, operation would be in low blower with mixture set for manual lean.

MAXIMUM ENDURANCE POWER CONDITIONS CHARTS.

These charts show the calibrated airspeed, engine settings, and fuel flow for maintaining maximum endurance speed with either four engines operating (figure A5-24), three engines operating (figure A5-25) or two engines operating (figure A5-26). Maximum endurance speed is slower than long range cruise speed, and is the speed which requires the mimimum power to maintain level flight.

The charts are based on standard atmospheric conditions. However, the calibrated airspeed and BHP/engine will remain unchanged for nonstandard conditions at the same density altitude. The RPM and fuel flow will increase slightly as temperature increases, while the BMEP will decrease slightly.

Sample Problem:

GIVEN: Engines operating = Four.

Gross weight = 100,000 pounds.

Cruise altitude = 15,000 feet.

FIND: CAS, BHP/engine, RPM, BMEP, and fuel flow for four engines.

1. Enter the Four-Engine Maximum Endurance Power Conditions chart (figure A5-24) at a gross weight of 100,000 pounds (A) and read vertically through the chart.

2. At the intersection of the 100,000-pound line and the 15,000-foot altitude curves, read across to the appropriate scale to find: CAS of 144 knots (B), BHP/engine of 965 BHP (B), RPM of 2040 (D), BMEP of 134 (E), and Fuel flow of 1750 pounds per hour (F).

3. The gross weight curve intersects the altitude curves in the solid portion of the curve; therefore, all operation would be in low blower with the mixture set for manual lean.

LEVEL FLIGHT PERFORMANCE CHARTS.

These charts show the power required to maintain level flight at any given airspeed and altitude with four engines operating (figure A5-27), three engines operating (figure A5-27) and two engines operating (figure A5-28). The charts are based on a clean configuration with cowl flaps set for adequate engine cooling on a standard day. They are applicable to nonstandard conditions if allowance is made for the small effect of a change in cowl flap setting on speed. On figure A5-27 chase-around lines illustrate the example.

Sample Problem:

GIVEN: Gross weight = 94,000 pounds

Density altitude = 20,000 feet.

FIND: Power required to maintain long range cruise speed (110 percent of $V_{L/D}$) with four engines operating.

1. Near center of chart locate intersection of 94, 000 pounds and the curve labeled "110 percent Speed For Maximum L/D."

2. Proceed horizontally to the left to 20, 000 feet density altitude and read the power required to maintain level flight, 1140 BHP per engine.

3. On the scale directly below point A, read the equivalent airspeed, 185 knots.

4. Continue straight down to 20, 000 feet density altitude and read the true airspeed, 253 knots.

POWER REQUIRED TO MAINTAIN 1.1 $V_{L/D}$ CHART.

A chart is provided (figure A5-29) to show the power required to maintain 110 percent of $V_{L/D}$ (long range cruise speed) in level flight at any given temperature, pressure altitude and gross weight. The chart is based on all engines operating. A chase-around line on the chart illustrates the example.

Sample Problem:

GIVEN: Outside air temperature = 16°C.

Pressure altitude = 15, 000 feet.

Gross weight = 100, 000 pounds.

FIND: Power required to maintain 1. 1 $V_{L/D}$.

1. Enter air temperature scale at -16°C.

2. Proceed vertically upwards to 15, 000 feet pressure altitude.

3. Turn horizontally to the right to the density altitude scale and note density altitude, 14, 900 feet.

4. Enter gross weight scale at 100, 000 pounds.

5. At intersection of 14, 900 feet density altitude and 100, 000 pounds gross weight, read the power required to maintain 1. 1 $V_{L/D}$, 1160 brake horsepower per engine.

RANGE PREDICTION CHARTS.

The range prediction charts (figures A5-30 through A5-35) are provided to determine the amount of fuel and the time required to cruise a given distance at various gross weights and cruise altitudes. The charts are based on cruise at the recommended long range cruise speeds and are not corrected for wind.

Figures A5-30 and A5-31 are based on four engines operating at density altitudes of 5, 000 to 20, 000 feet. Figures A5-32 and A5-33 are based on three engines operating at density altitudes of 5, 000 to 15, 000 feet. Figures A5-34 and A5-35 are based on two engines operating and density altitudes of sea level to 10, 000 feet.

The charts may also be used to determine the range that may be obtained from a given amount of fuel. The following example illustrates the use of the chart to determine cruise fuel and cruise time for initial flight planning.

Sample Problem:

GIVEN: Final cruise weight at destination = 72, 500 pounds.

Cruise altitude = 10, 000 feet.

Cruise distance = 1500 nautical miles.

FIND: Fuel and time required to cruise 1500 nautical miles.

1. Enter the distance chart (figure A5-30) at final cruise weight of 72, 500 pounds (A).

2. Read up to cruise altitude of 10, 000 feet (B).

3. Read across to range scale for range at final cruise weight of 6780 nautical miles (C).

4. Subtract cruise distance of 1500 nautical miles (D) from (C) to obtain range at initial cruise weight of 5280 nautical miles (E).

5. Read across from (E) to cruise altitude of 10, 000 feet (F), and down to find initial gross weight of 82, 500 pounds (G).

6. Fuel required is the final cruise weight (A) subtracted from the initial cruise weight (G), or 82,500 -72,500 = 10,000 pounds of fuel required.

7. To find the time required for cruise, enter the time chart (figure A5-31) with the final cruise weight of 72, 500 pounds (A) and read up to the cruise altitude of 10, 000 feet (B).

8. Read across to the time scale to time at final cruise weight of 28. 5 hours (C).

9. Enter with the initial cruise weight obtained from the distance chart of 82, 500 pounds (D).

10. Read up to cruise altitude of 10, 000 feet (E) and across to the time at initial cruise weight of 20. 7 hours (F).

11. Cruise time is initial time (F) subtracted from the final time (C) or 28. 5 -20. 7 = 7. 8 hours (G).

POWER SETTINGS FOR CRUISE TABLES.

The even numbered tables (figures A5-36 through A5-60) and figures A5-61 through A5-63, show the engine settings necessary to develop a given brake horsepower for various pressure altitudes and carburetor air temperatures. Power settings shown above the heavy line on the table are for operation in high blower and those below the heavy line are for operation in low blower.

Each table is for a single brake horsepower. Tables are provided for each 50 brake horsepower from 700 to 1200 based on a 12 BMEP drop from best power mixture setting. Two additional tables are provided for 1240 BHP (maximum cruise power in low blower), one based on 12 BMEP drop, and one based on 2 BMEP drop from best power mixture. Fuel flows are lower on the 12 BMEP table than on the 2 BMEP table, however, the use of the 2 BMEP drop permits operation at higher altitudes. Facing each power setting table is a table showing the cruise speeds for that brake horsepower.

Additional tables are provided for operation in auto rich at 1300, 1500, and 1700 BHP. Cruise speeds are not provided for these power settings.

The following example illustrates the method of using the table and the different power settings that may be expected due to a difference in carburetor air temperature.

Sample Problem:

GIVEN: Desired cruise power = 950 BHP/Engine.

Cruise pressure altitude = 17, 000 feet.

Carburetor air temperature = 0°C.

FIND: Power settings necessary to maintain 950 BHP.

1. Select table for 950 BHP/Engine (figure A5-46).
2. Enter the table at 17, 000 pressure altitude (A) and carburetor air temperature of 0°C (B).
3. Read across and down, disregarding the guide lines on the table, to the intersection of altitude and temperature, to find the manifold pressure for these conditions of 27. 9 in. Hg (C).
4. Follow between the guide lines, reading to the right, to find RPM of 2200 in LOW blower, BMEP drop of 12 psi, fuel flow of 444 lb/hr/eng, and a normal BMEP of 122 psi at (D).

NOTE

To illustrate power settings changes necessary for a change in CAT, assume a carburetor air temperature of +20°C for the same conditions.

5. Entering the table with the same altitude, but with a CAT of +20°C (E), find manifold pressure of 31. 2 in. Hg (F) as in steps 2 and 3.
6. Follow between the guide lines to find RPM of 2100 in HIGH blower, BMEP drop of 12 psi, fuel flow of 450 lb/hr/eng, and nominal BMEP of 128 psi at (G).

From these examples it is noted that the guide lines are used only after manifold pressure has been determined from the altitude and CAT.

CRUISE SPEED TABLES.

The odd numbered tables (figures A5-37 through A5-59) show the indicated airspeed and the true airspeed resulting from any given cruise power at any given density altitude and gross weight. Each chart is for a single brake horsepower. There is a chart for each 50 brake horsepower from 700 to 1200. An additional chart for 1240 BHP (maximum cruise power in low blower) is included. Cruise speeds for 1240 BHP are the same for both 12 BMEP and 2 BMEP drop. Facing each cruise speed table is a table showing the engine settings necessary to develop that brake horsepower.

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: LEAN—FLIGHT TEST
RICH—CALCULATED DATA

SEA LEVEL – STANDARD DAY
LOW BLOWER
$1/\sqrt{\sigma} = 1.0000$

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

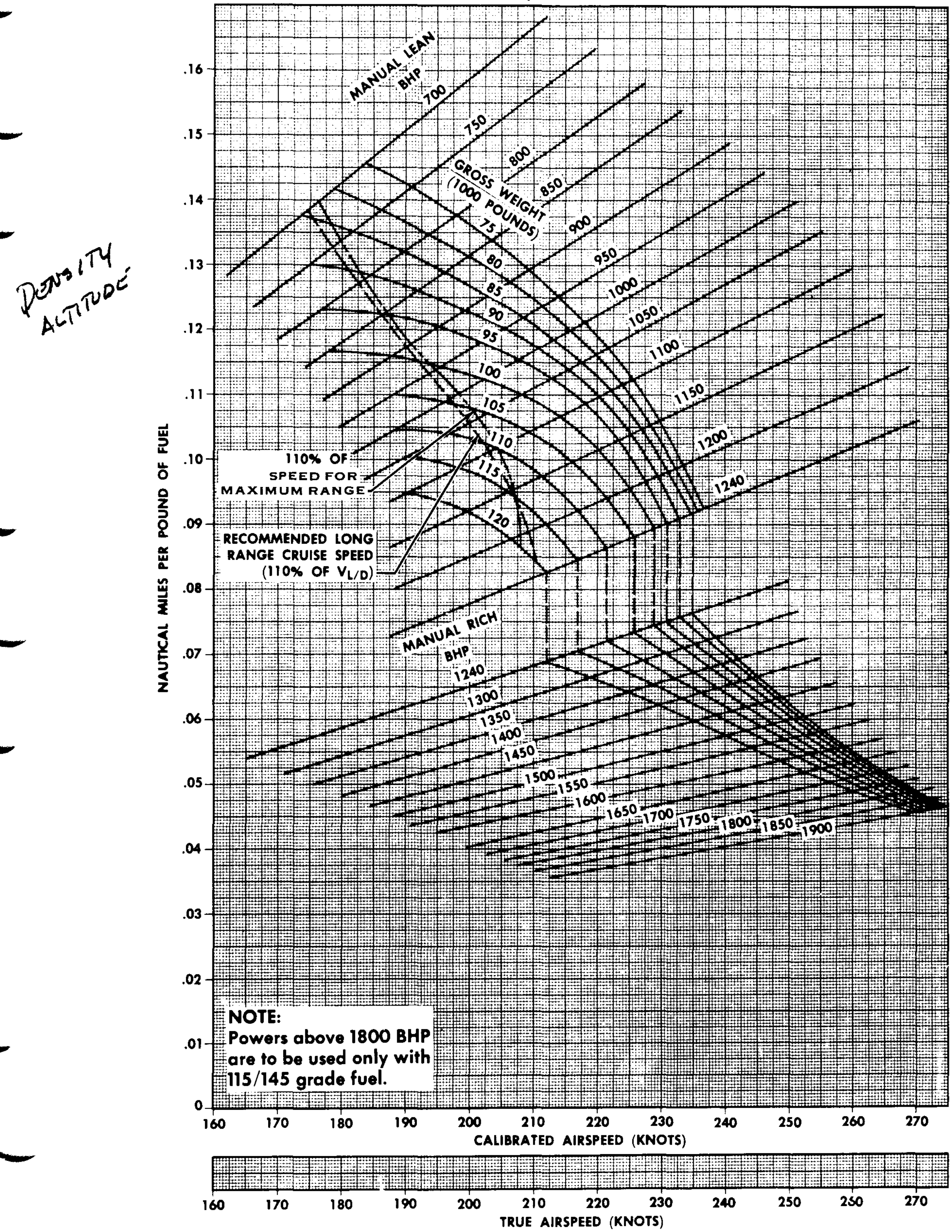


Figure A5-1. Nautical Miles Per Pound of Fuel - Four-Engine - Sea Level

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

1000 FEET AND 2000 FEET – STANDARD DAY

LOW BLOWER

MODEL: C-118A AND VC-118A
DATA AS OF: 2-15-59
DATA BASIS: LEAN-FLIGHT TEST
RICH-CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
Powers above 1800 BHP are to be used only with 115/145 grade fuel.

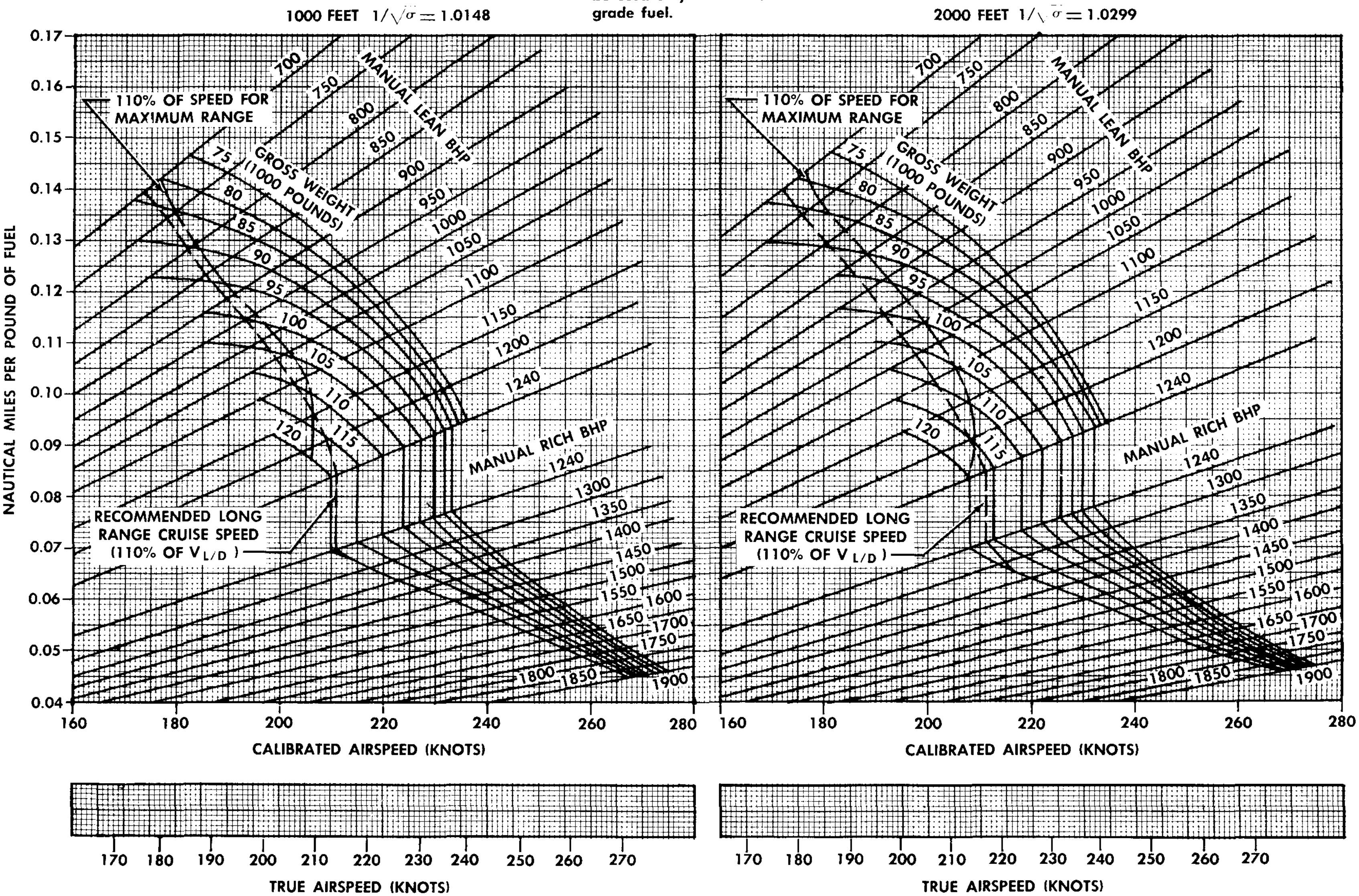


Figure A5-2. Nautical Miles Per Pound of Fuel - Four-Engine - 1000 Feet and 2000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

3000 FEET AND 4000 FEET – STANDARD DAY

LOW BLOWER

MODEL: C-118A AND VC-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN-FLIGHT TEST
RICH-CALCULATED DATA

NOTE:
Powers above 1800 BHP are to be used only with 115/145 grade fuel.

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

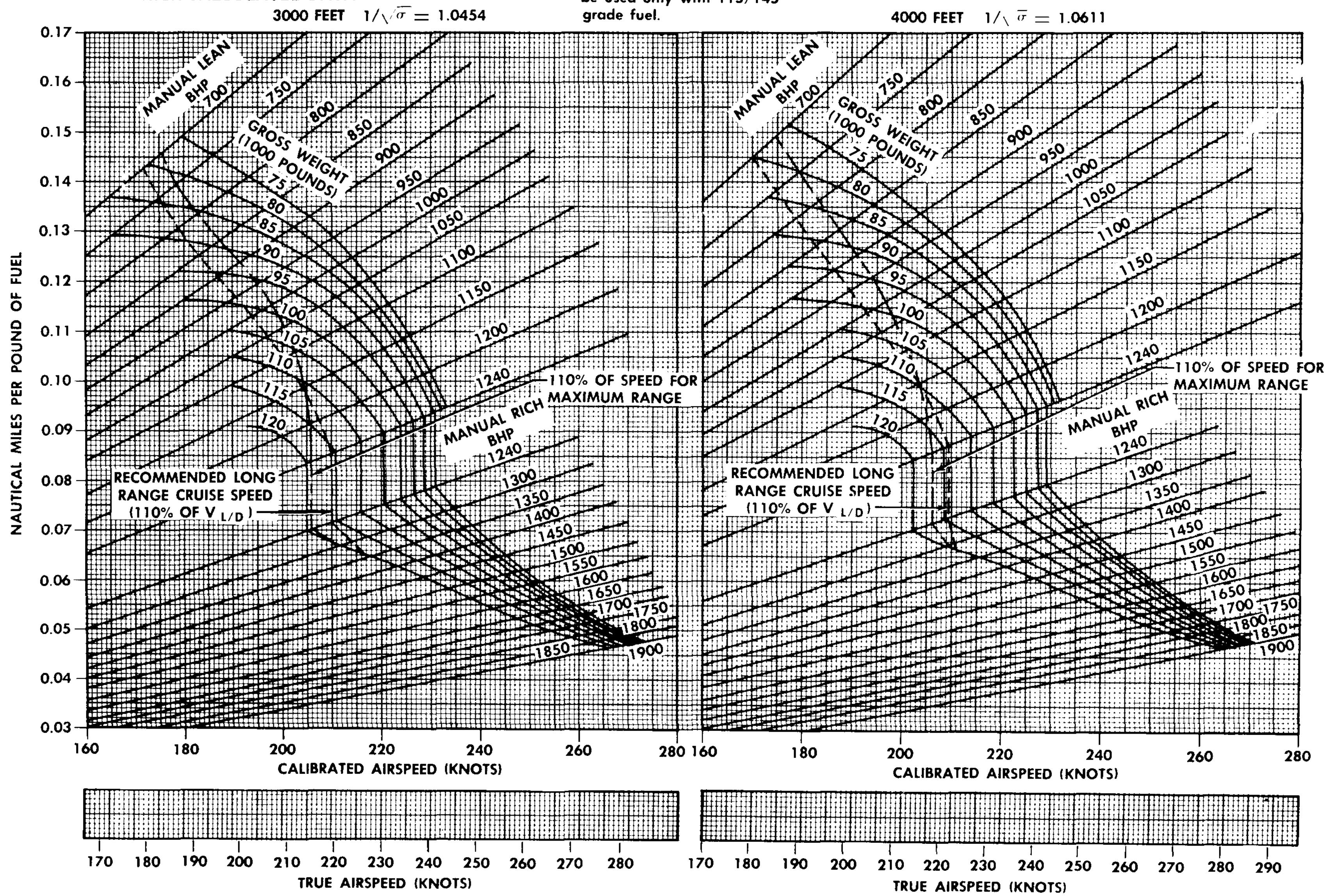


Figure A5-3. Nautical Miles Per Pound of Fuel - Four-Engine - 3000 Feet and 4000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

5,000 FEET – STANDARD DAY

LOW BLOWER

$1/\sqrt{\sigma} = 1.0773$

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: LEAN—FLIGHT TEST
RICH—CALCULATED DATA

ENGINES:
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

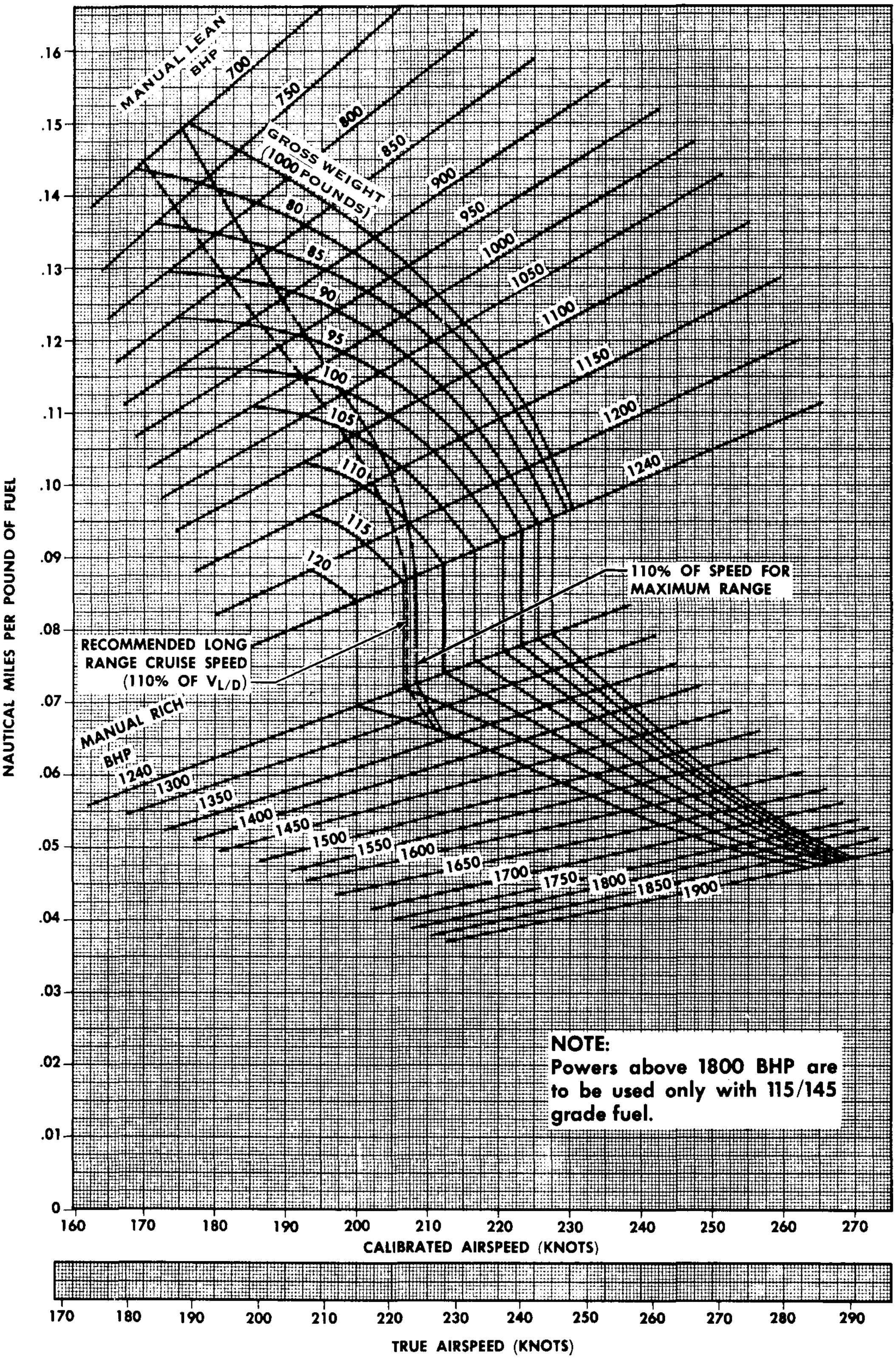


Figure A5-4. Nautical Miles Per Pound of Fuel - Four-Engine - 5000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

6000 FEET AND 7000 FEET – STANDARD DAY

LOW BLOWER

MODEL: C-118A AND VC-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN-FLIGHT TEST
RICH-CALCULATED DATA

NOTE:
Powers above 1800 BHP are to be used only with 115/145 grade fuel.

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

6000 FEET $1/\sqrt{\sigma} = 1.0938$

7000 FEET $1/\sqrt{\sigma} = 1.1107$

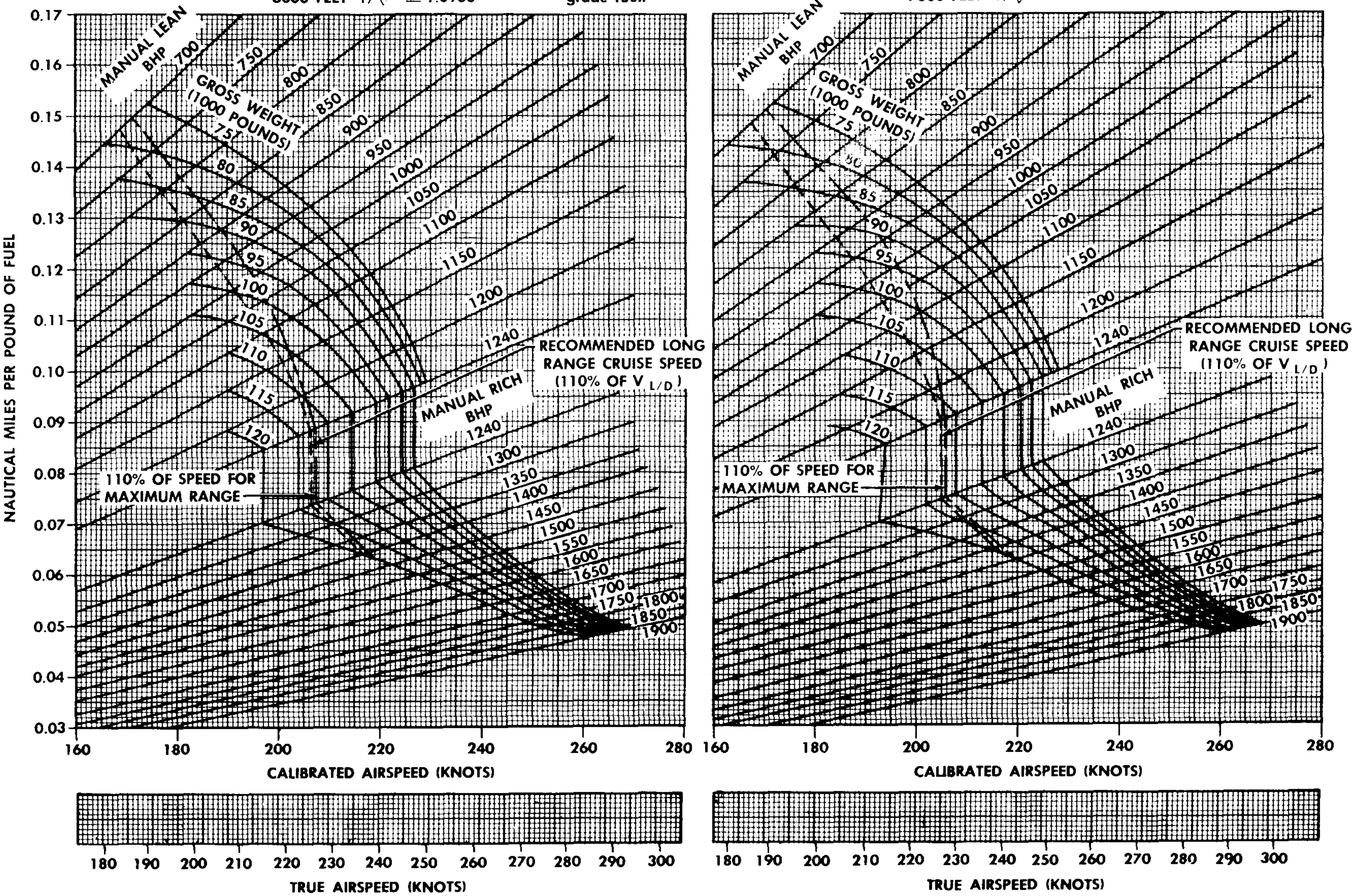


Figure A5-5. Nautical Miles Per Pound of Fuel - Four-Engine - 6000 Feet and 7000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

8000 FEET AND 9000 FEET – STANDARD DAY

LOW BLOWER

MODEL: C-118A AND VC-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN-FLIGHT TEST
RICH-CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

NOTE:
Powers above 1800 BHP are to be used only with 115/145 grade fuel.

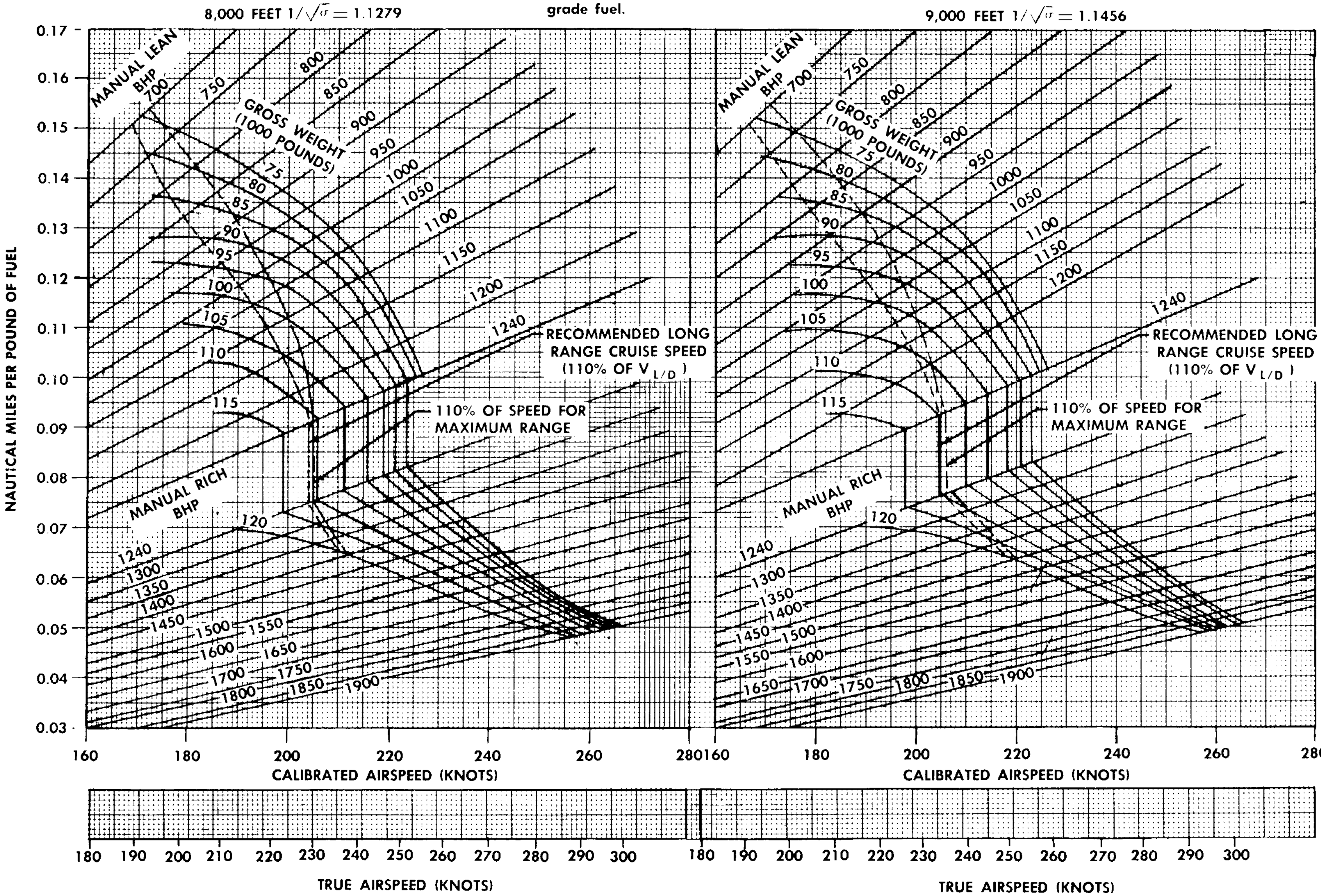


Figure A5-6. Nautical Miles Per Pound of Fuel - Four-Engine - 8000 Feet and 9000 Feet

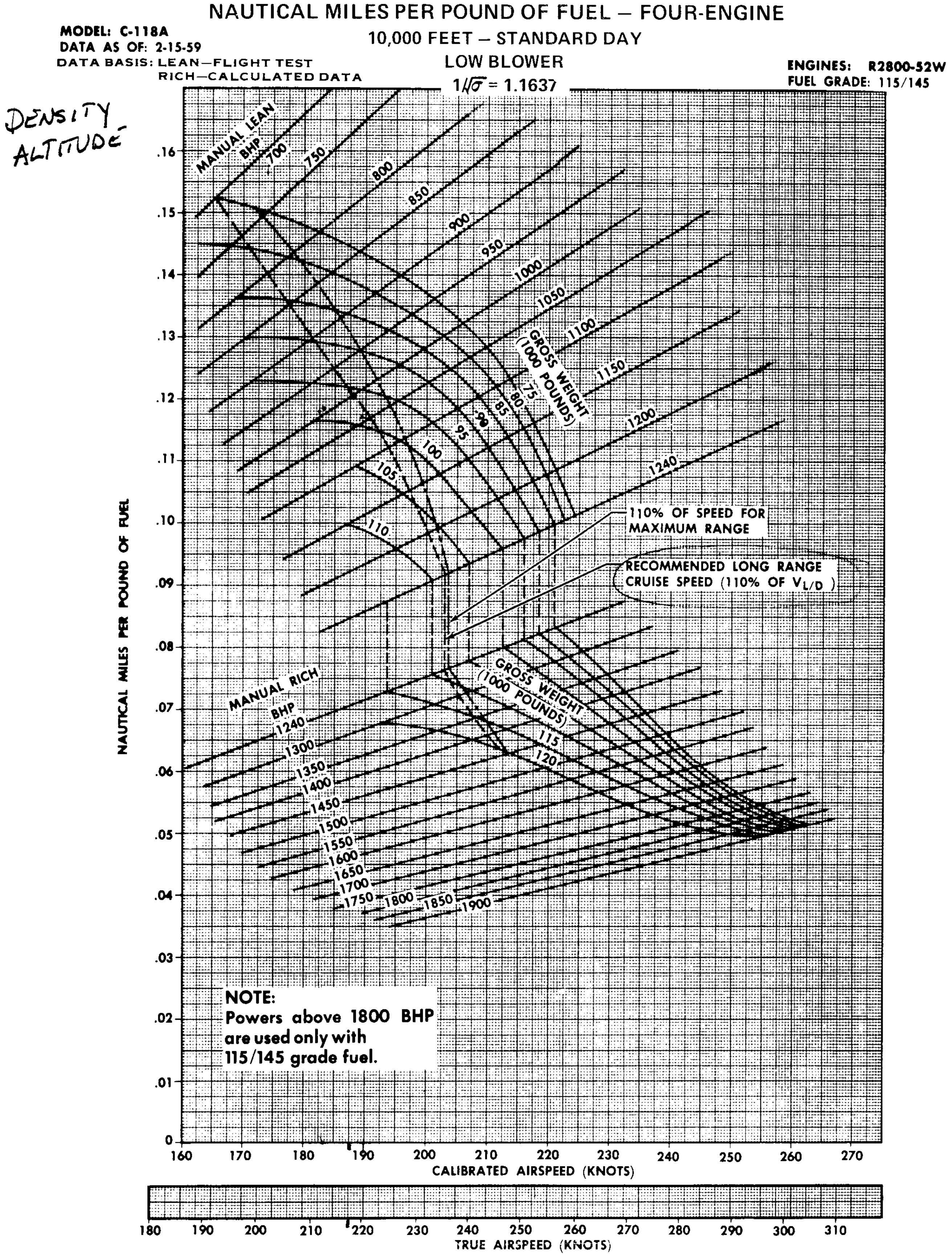


Figure A5-7. Nautical Miles Per Pound of Fuel - Four-Engine - 10,000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

11,000 FEET AND 12,000 FEET – STANDARD DAY
LOW BLOWER

MODEL: C-118A AND VC-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN-FLIGHT TEST
RICH-CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

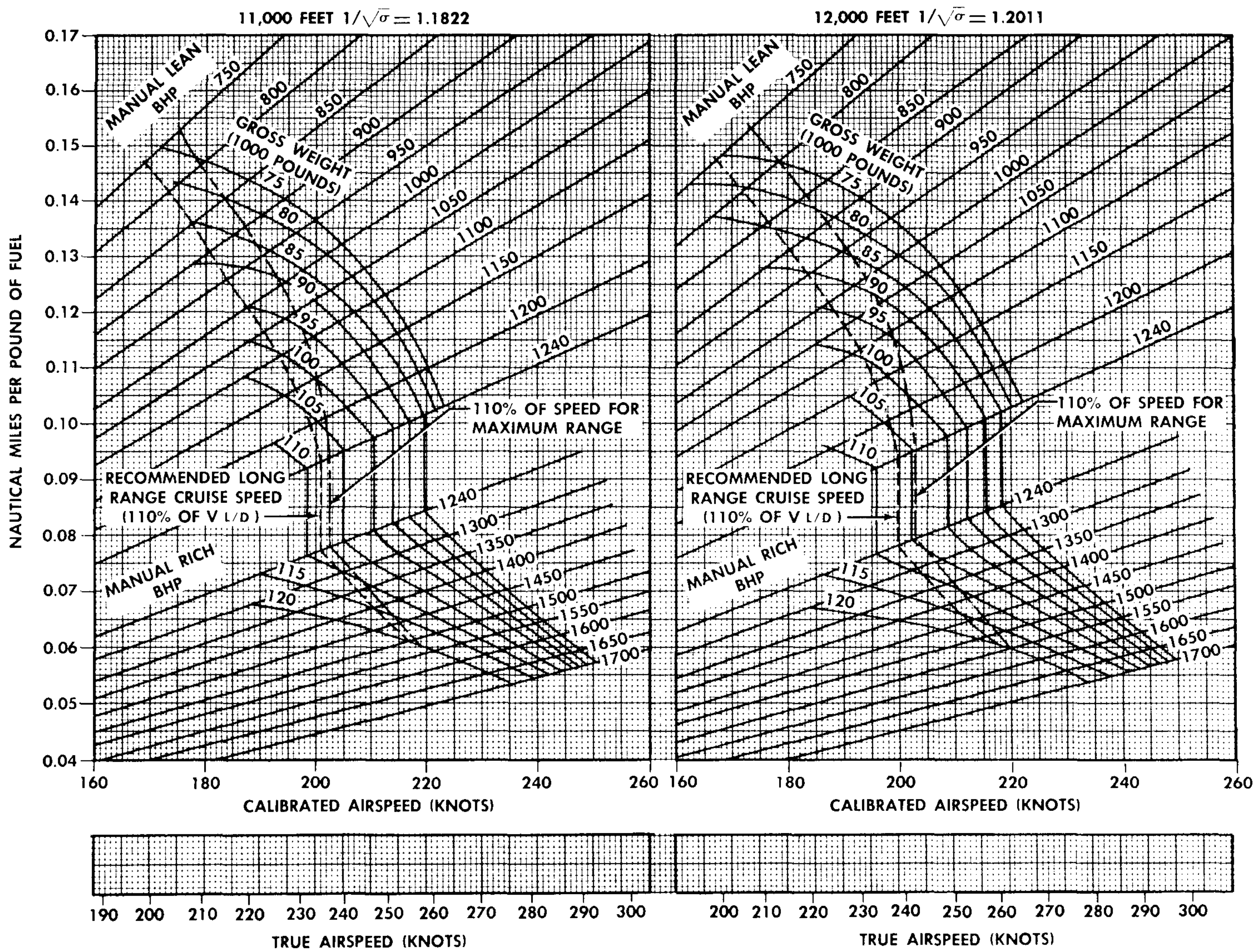


Figure A5-8. Nautical Miles Per Pound of Fuel - Four-Engine - 11,000 Feet and 12,000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

13,000 FEET AND 14,000 FEET – STANDARD DAY

LOW BLOWER

MODEL: C-118A AND VC-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN-FLIGHT TEST
RICH-CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

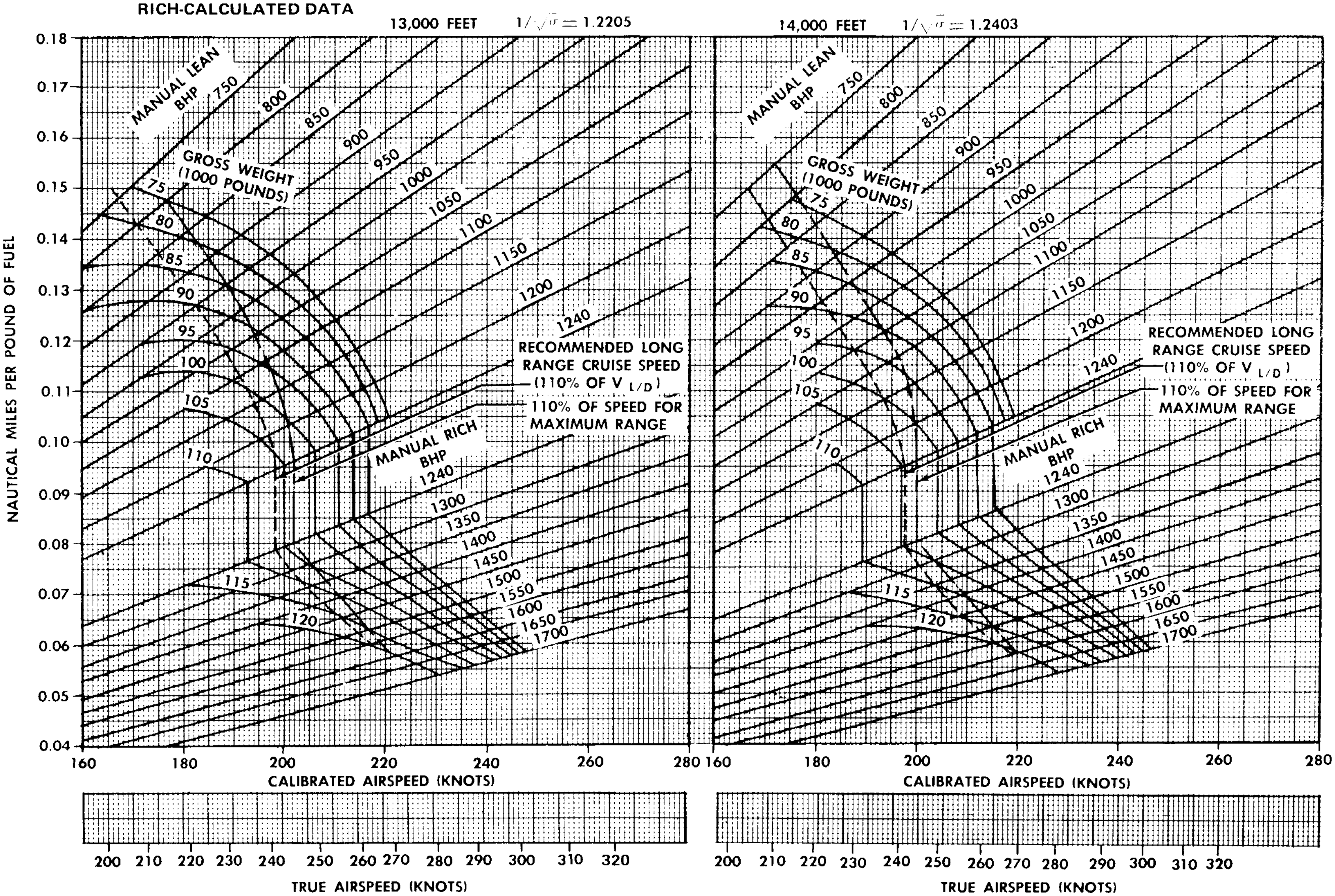


Figure A5-9. Nautical Miles Per Pound of Fuel - Four-Engine - 13,000 Feet and 14,000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

15,000 FEET – STANDARD DAY

LOW BLOWER

$1/\sqrt{\sigma} = 1.2608$

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: LEAN—FLIGHT TEST
RICH—CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

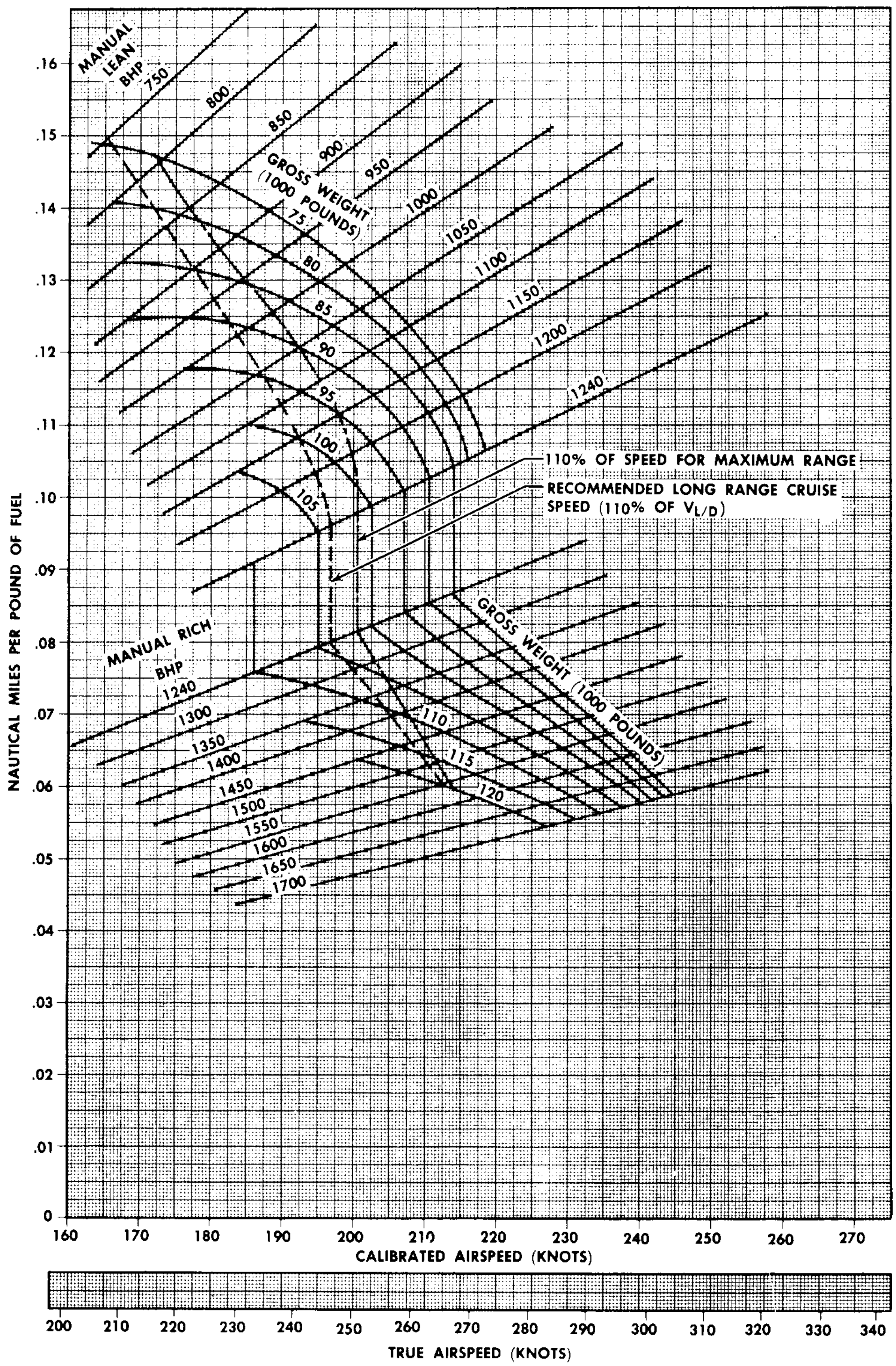


Figure A5-10. Nautical Miles Per Pound of Fuel - Four-Engine - 15,000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

16,000 FEET AND 17,000 FEET – STANDARD DAY

MODEL: C-118A AND VC-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN-FLIGHT TEST
RICH-CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

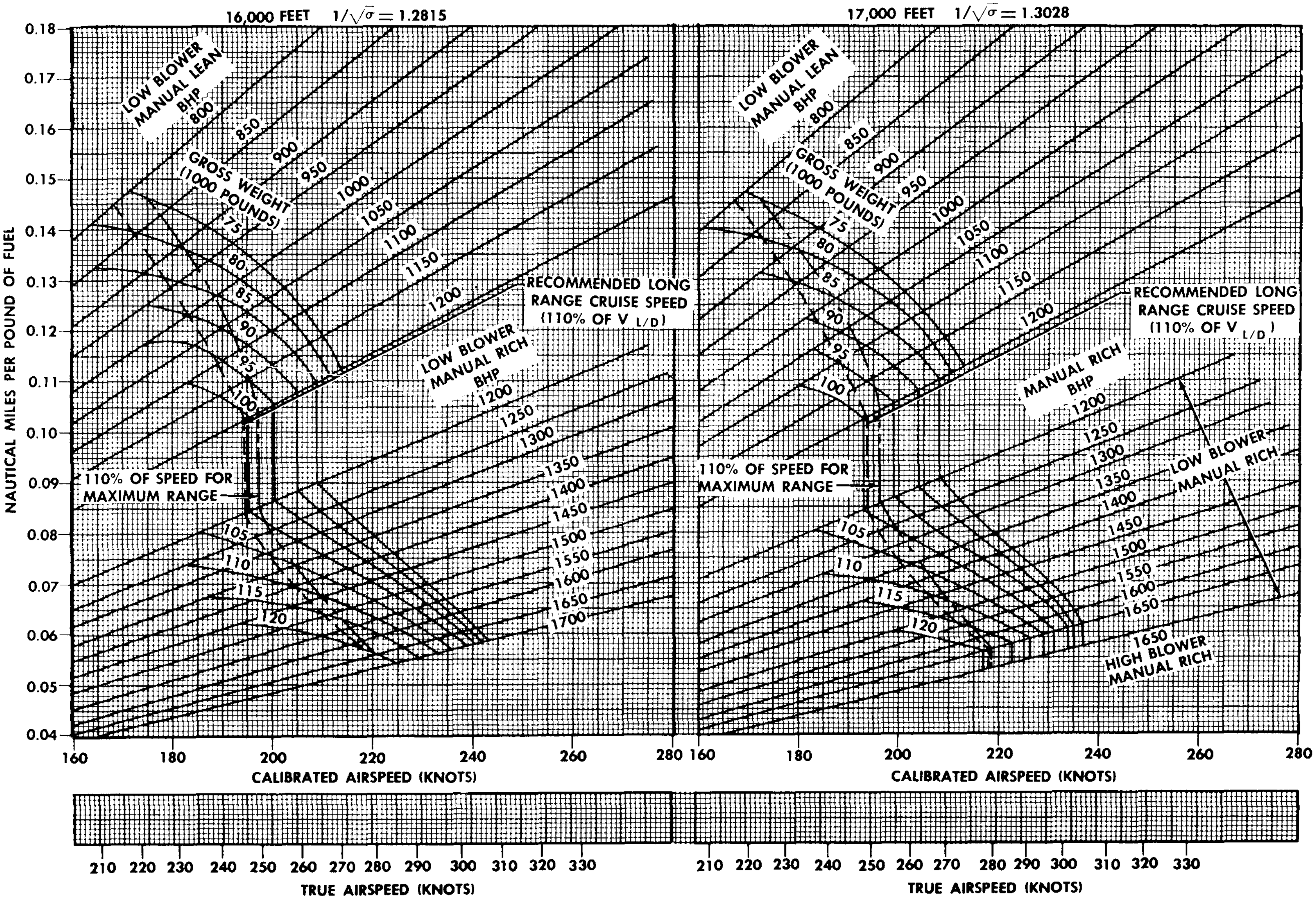


Figure A5-11. Nautical Miles Per Pound of Fuel - Four-Engine - 16,000 Feet and 17,000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE
18,000 FEET AND 19,000 FEET – STANDARD DAY

MODEL: C-118A AND VC-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN-FLIGHT TEST
RICH-CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

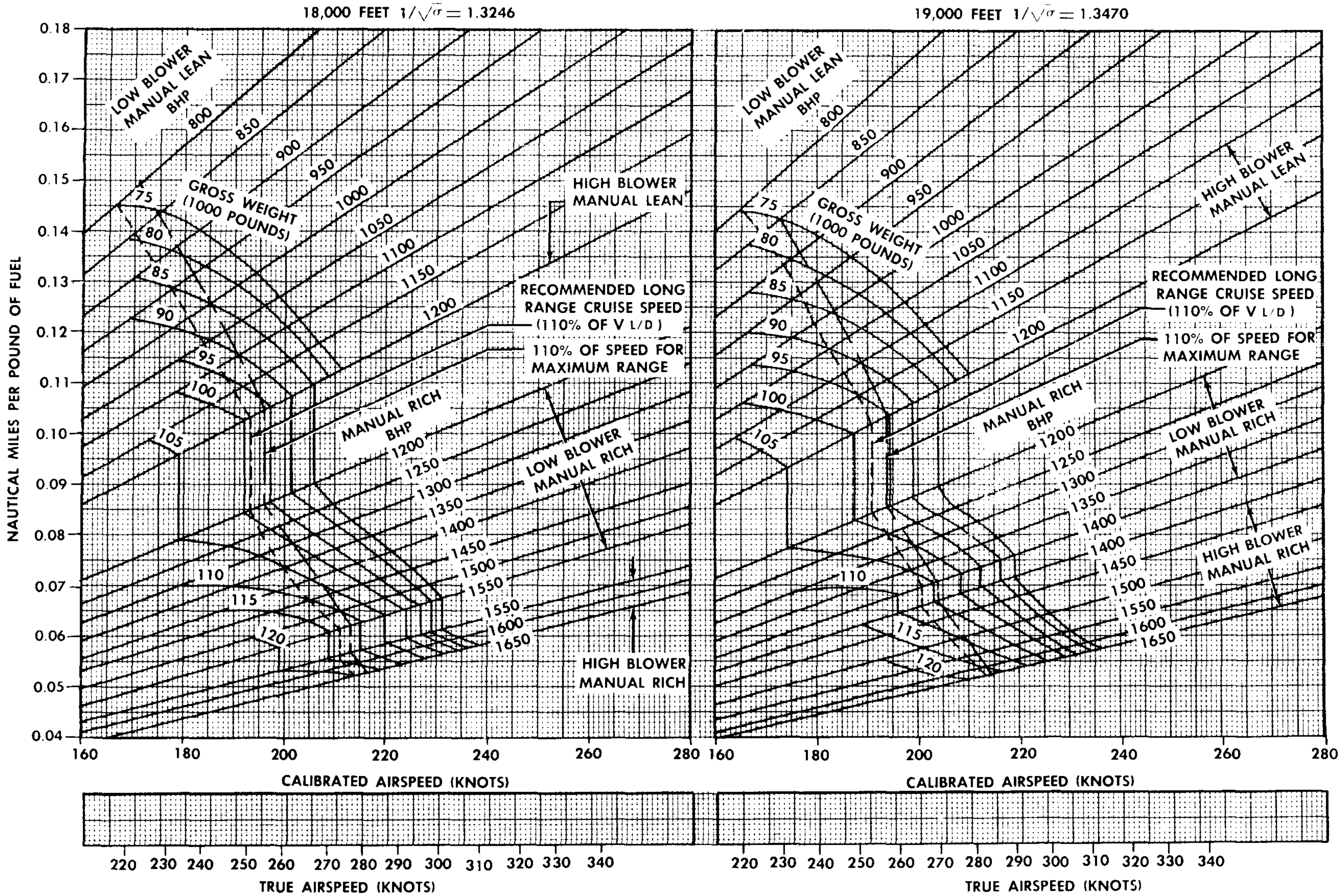


Figure A5-12. Nautical Miles Per Pound of Fuel - Four-Engine - 18,000 Feet and 19,000 Feet

NAUTICAL MILES PER POUND OF FUEL – FOUR-ENGINE

20,000 FEET – STANDARD DAY

$1/\sqrt{\sigma} = 1.3701$

MODEL: C-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN-FLIGHT TEST
RICH-CALCULATED

ENGINES: R2800-52W

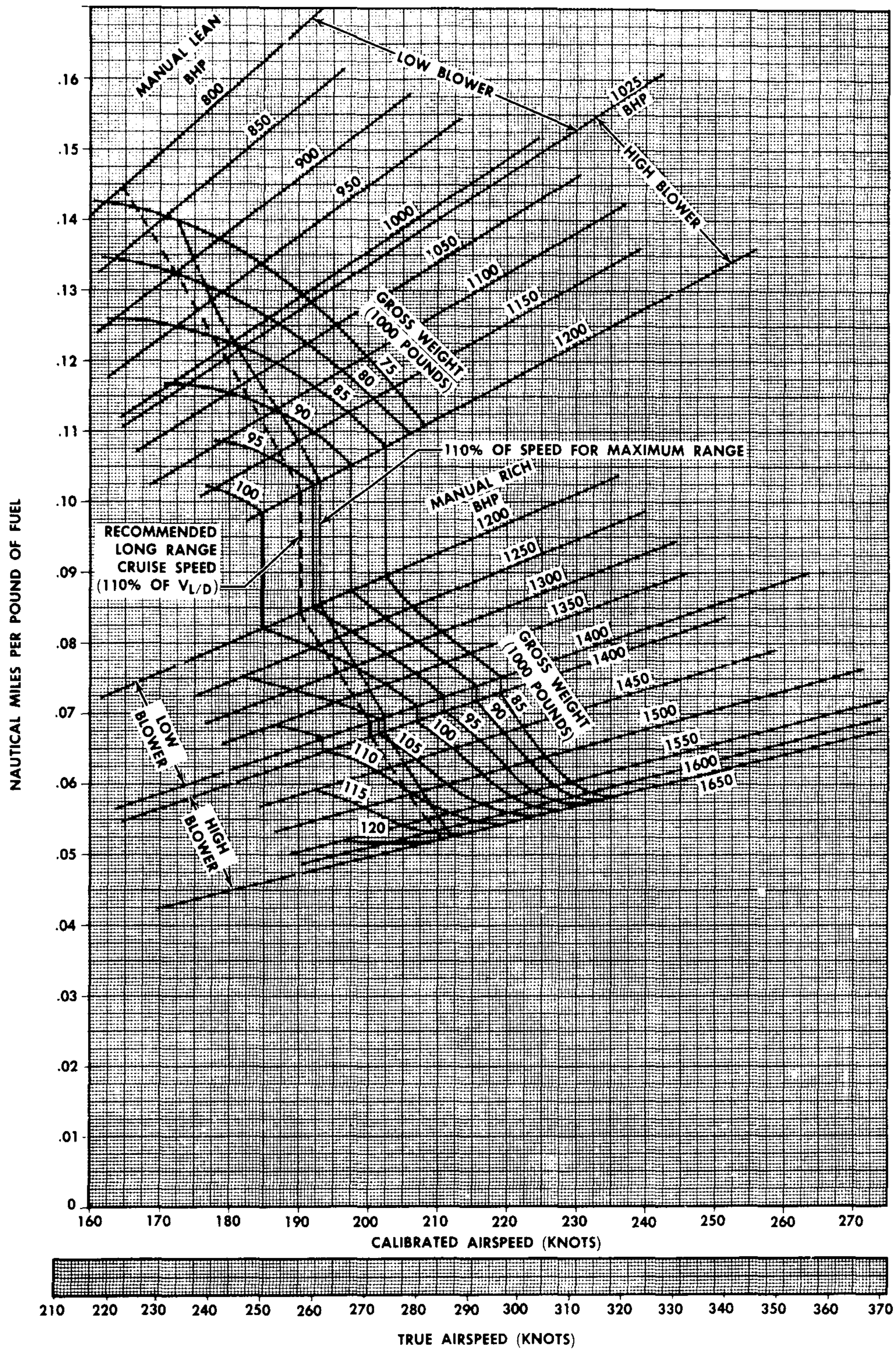


Figure A5-13. Nautical Miles Per Pound of Fuel - Four-Engine - 20,000 Feet

NAUTICAL MILES PER POUND OF FUEL — THREE-ENGINE

SEA LEVEL — STANDARD DAY

LOW BLOWER

$1/\sqrt{\sigma} = 1.0000$

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: LEAN—FLIGHT TEST
RICH—CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

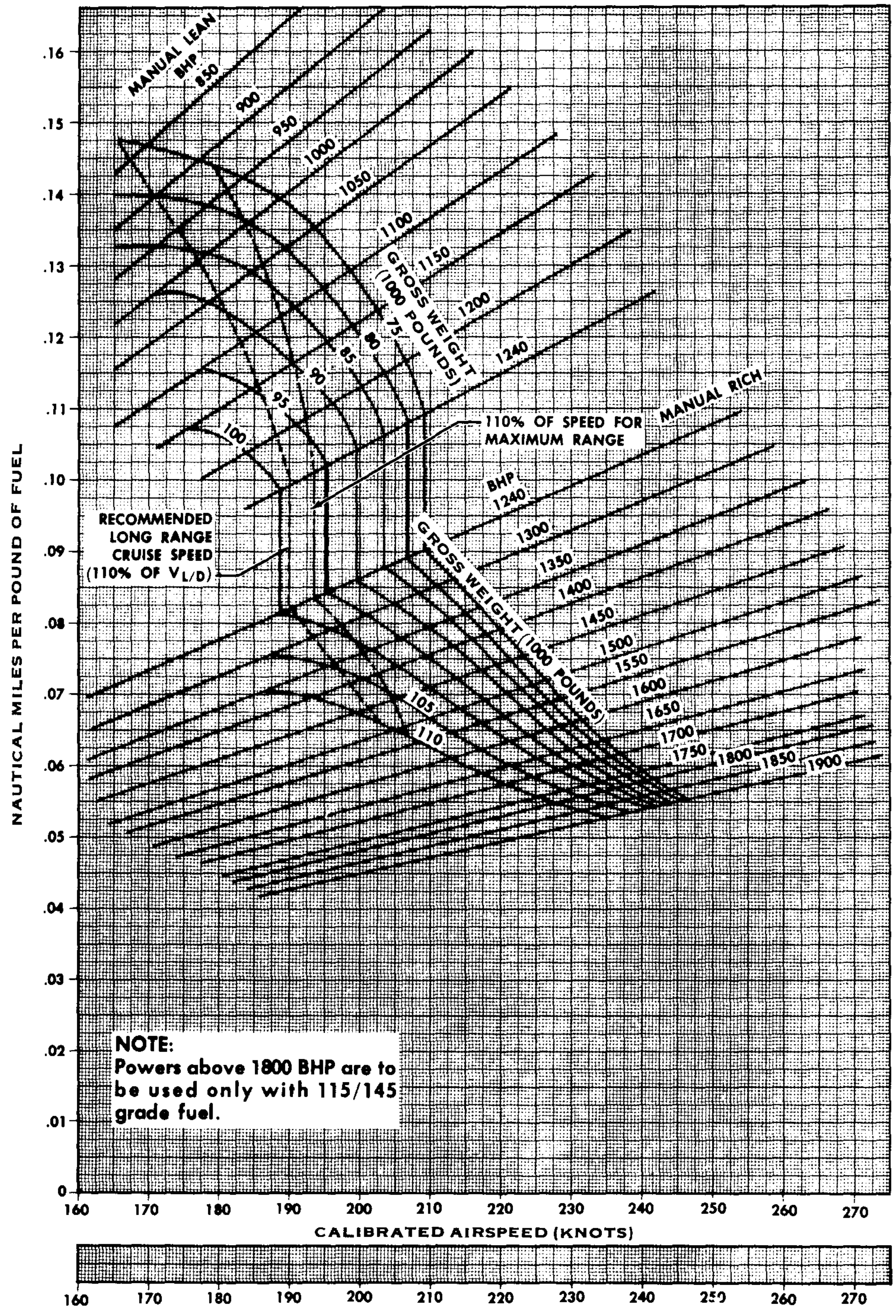


Figure A5-14. Nautical Miles Per Pound of Fuel - Three-Engine - Sea Level

NAUTICAL MILES PER POUND OF FUEL – THREE-ENGINE

5000 FEET – STANDARD DAY

LOW BLOWER

$1/\sqrt{\sigma} = 1.0773$

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: LEAN—FLIGHT TEST
RICH—CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

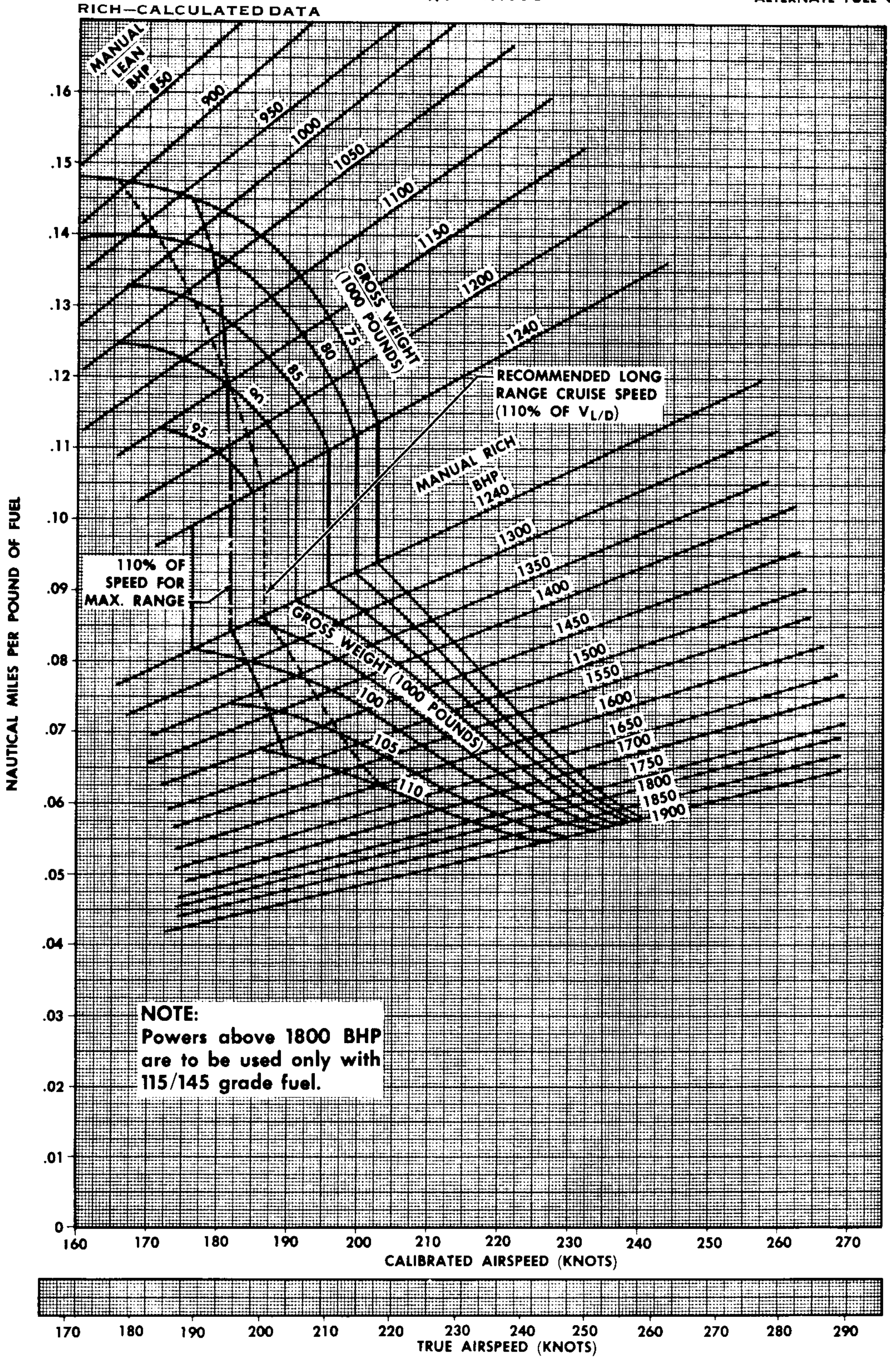


Figure A5-15. Nautical Miles Per Pound of Fuel - Three-Engine - 5000 Feet

NAUTICAL MILES PER POUND OF FUEL – THREE-ENGINE

10,000 FEET – STANDARD DAY

LOW BLOWER

$1/\sqrt{\sigma} = 1.1637$

MODEL: C-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN—FLIGHT TEST
RICH—CALCULATED DATA

ENGINES: R2800-52W

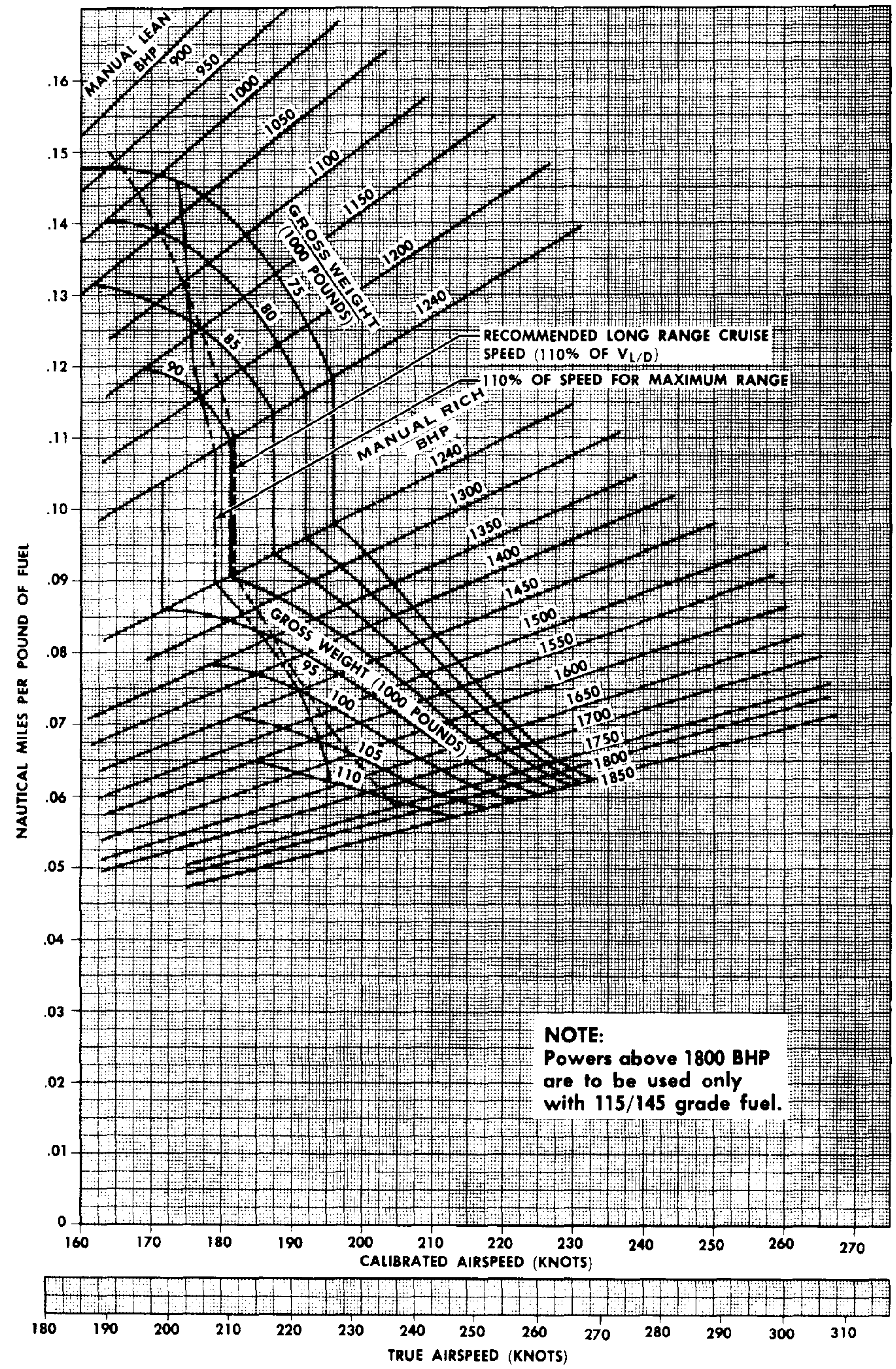


Figure A5-16. Nautical Miles Per Pound of Fuel - Three-Engine - 10,000 Feet

NAUTICAL MILES PER POUND OF FUEL – THREE-ENGINE

15,000 FEET – STANDARD DAY

$1/\sqrt{\sigma} = 1.2608$

MODEL: C-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN - FLIGHT TEST
RICH - CALCULATED

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

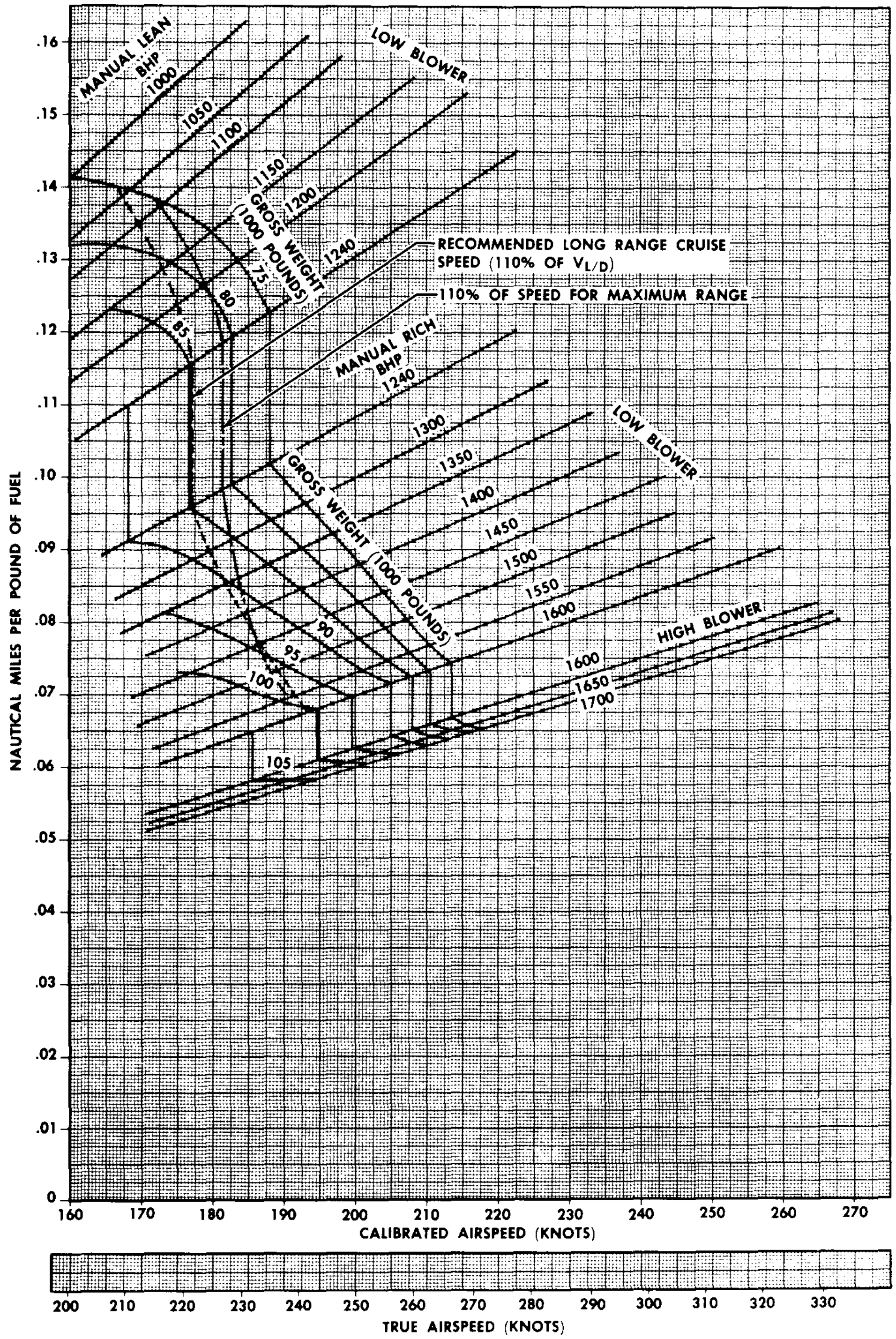


Figure A5-17. Nautical Miles Per Pound of Fuel - Three-Engine - 15,000 Feet

NAUTICAL MILES PER POUND OF FUEL – TWO-ENGINE
SEA LEVEL – STANDARD DAY
LOW BLOWER

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: CALCULATED DATA

$\frac{1}{\sqrt{\sigma}} = 1.0000$

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

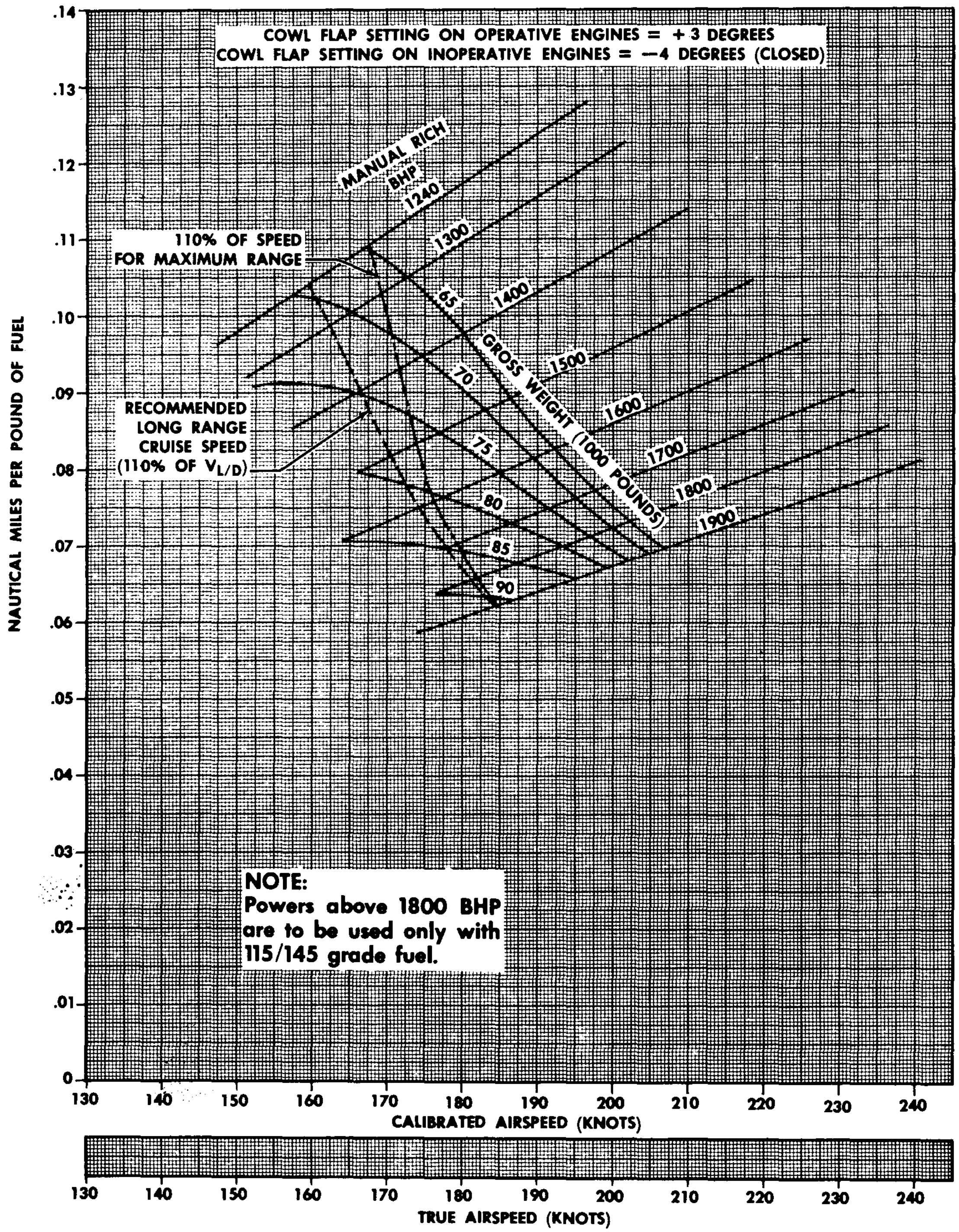


Figure A5-18. Nautical Miles Per Pound of Fuel - Two-Engine - Sea Level

NAUTICAL MILES PER POUND OF FUEL – TWO-ENGINE

5000 FEET – STANDARD DAY

LOW BLOWER

$1/\sqrt{\sigma} = 1.0773$

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

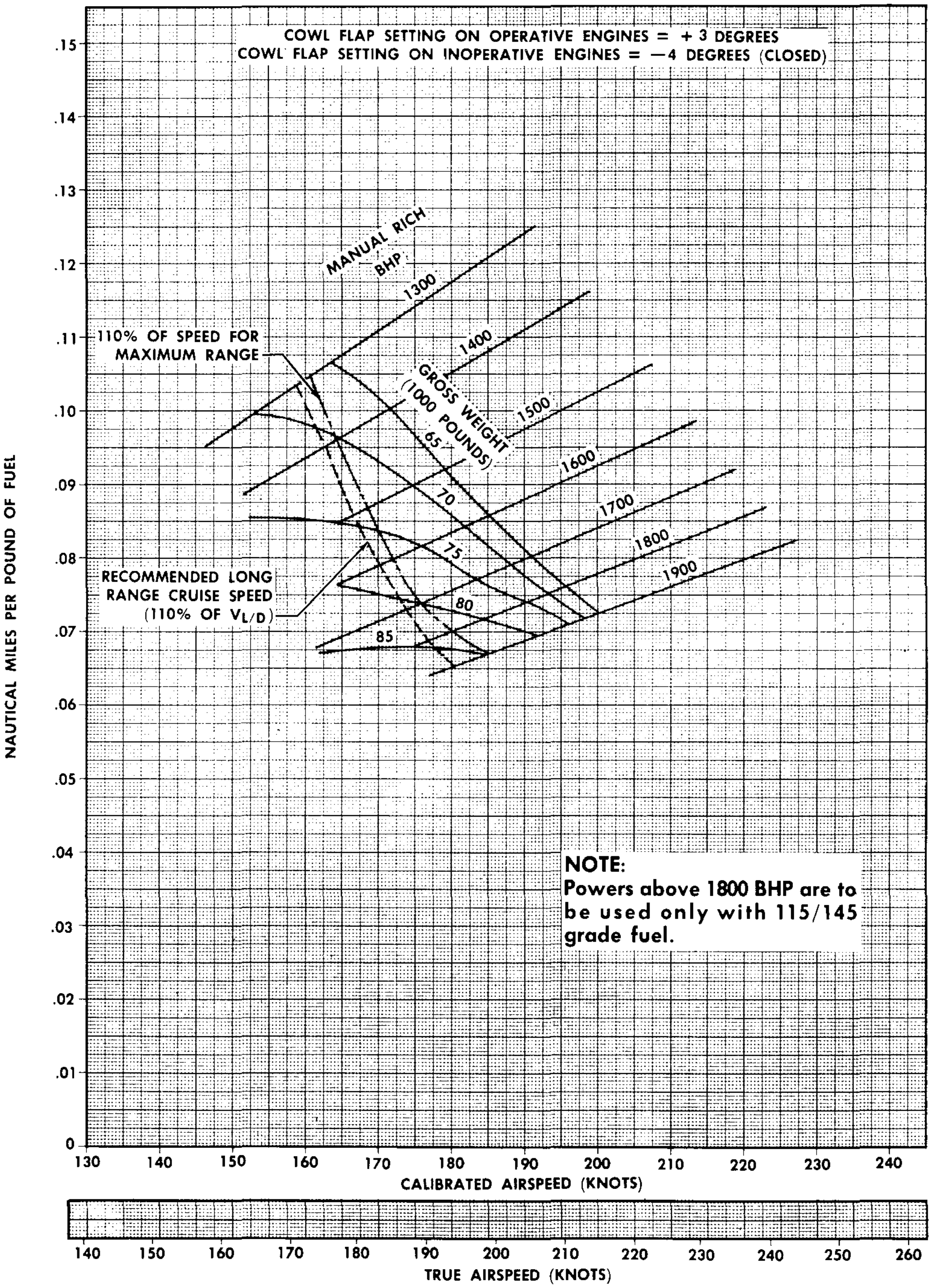


Figure A5-19. Nautical Miles Per Pound of Fuel - Two-Engine - 5000 Feet

NAUTICAL MILES PER POUND OF FUEL – TWO-ENGINE

10,000 FEET – STANDARD DAY
LOW BLOWER
$1/\sqrt{\sigma} = 1.1637$

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

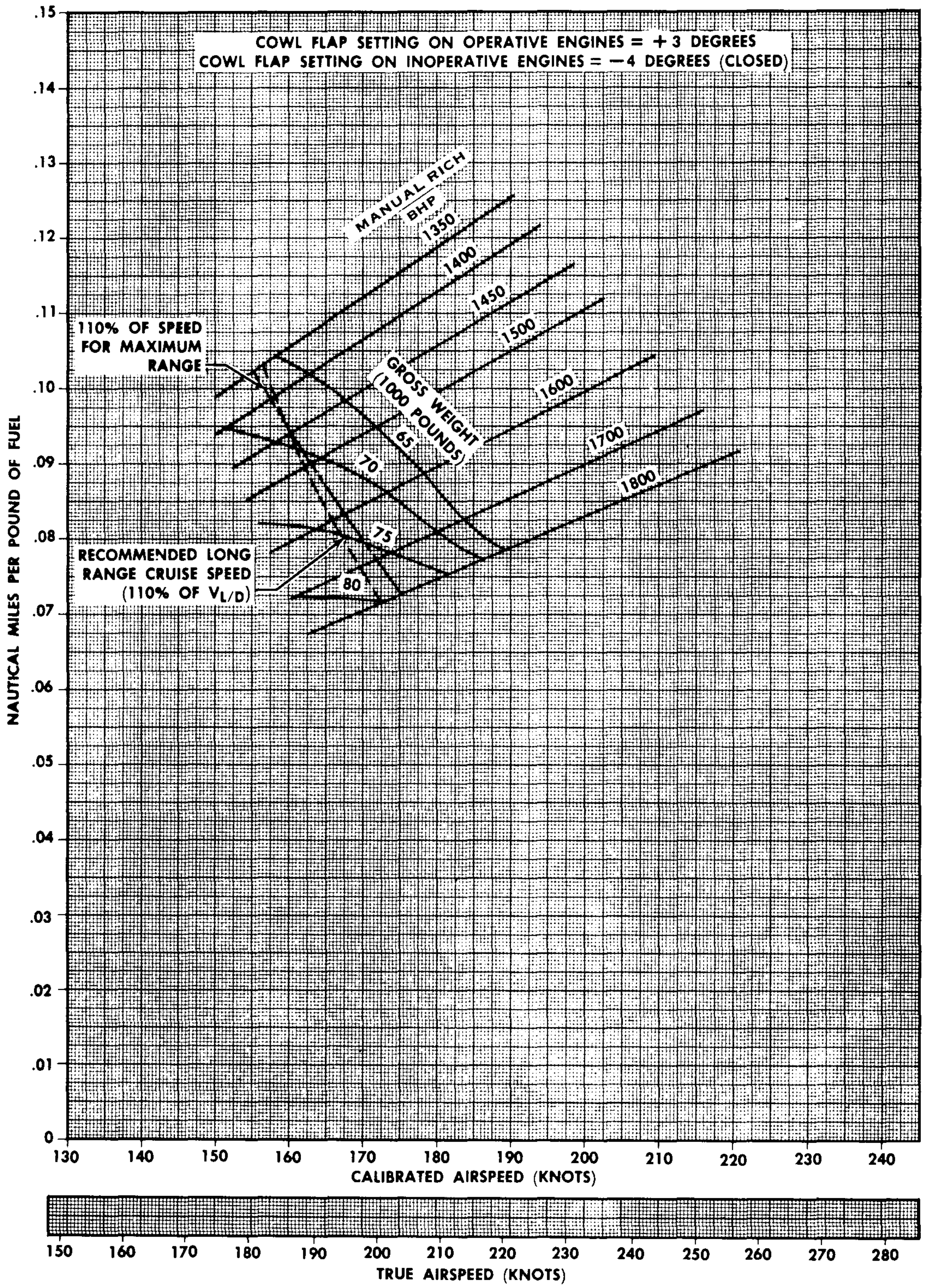


Figure A5-20. Nautical Miles Per Pound of Fuel - Two-Engine - 10,000 Feet

FOUR-ENGINE LONG RANGE SUMMARY
STANDARD DAY

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: LEAN—FLIGHT TEST
RICH—CALCULATED DATA

ENGINE(S): R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

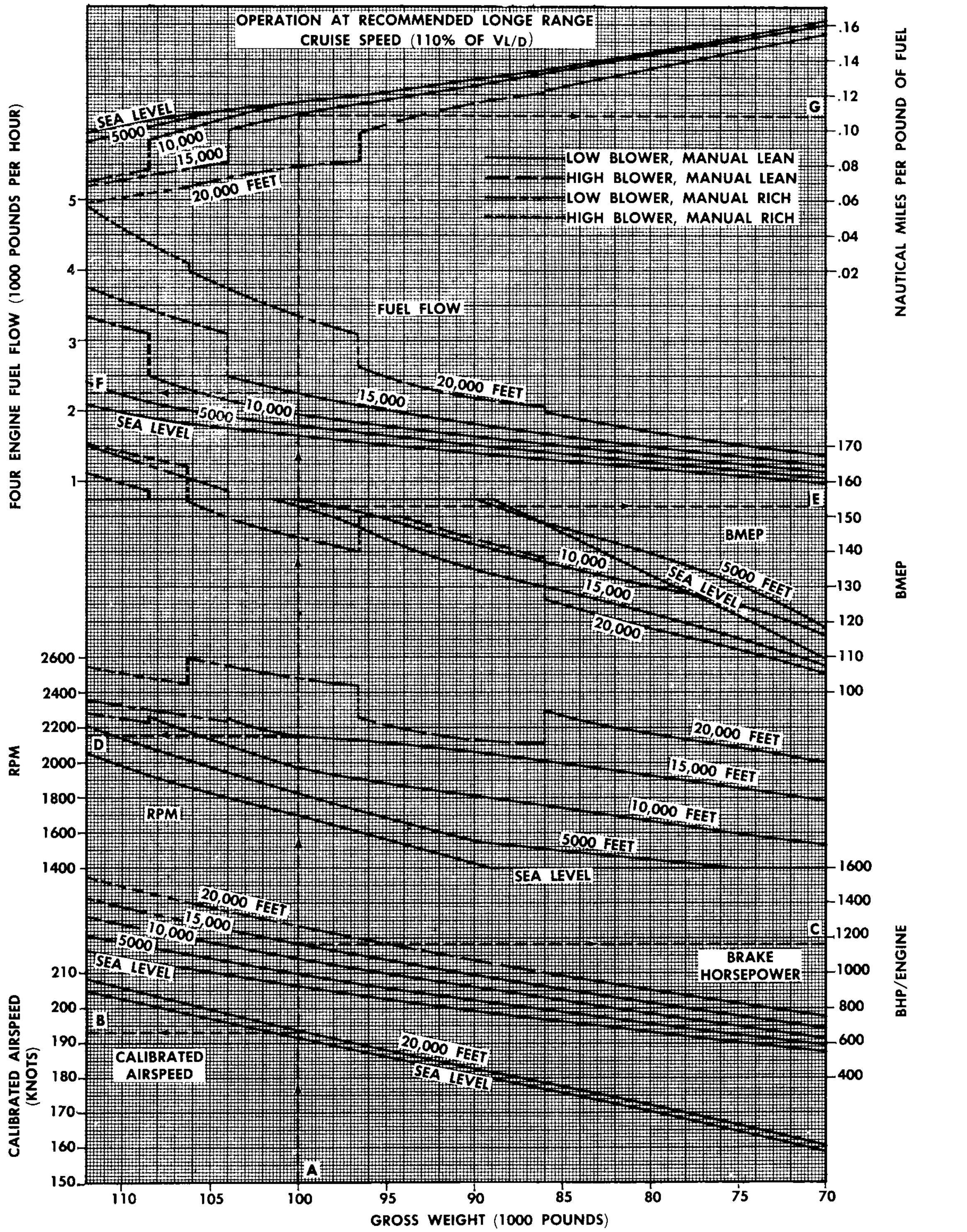


Figure A5-21. Four-Engine Long Range Summary

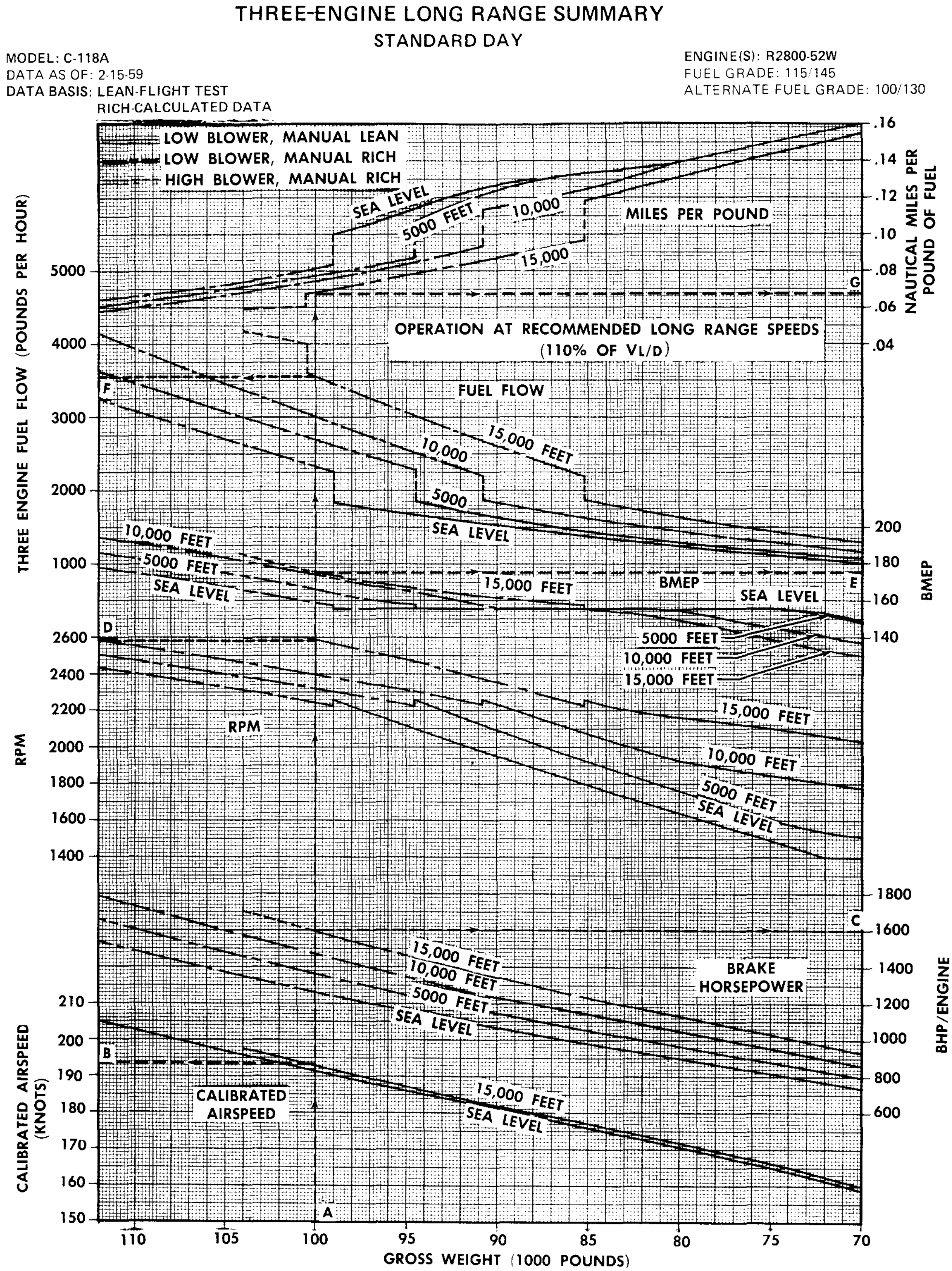


Figure A5-22. Three-Engine Long Range Summary

TWO-ENGINE LONG RANGE SUMMARY
STANDARD DAY
LOW BLOWER MANUAL RICH

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: CALCULATED DATA

ENGINES: R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

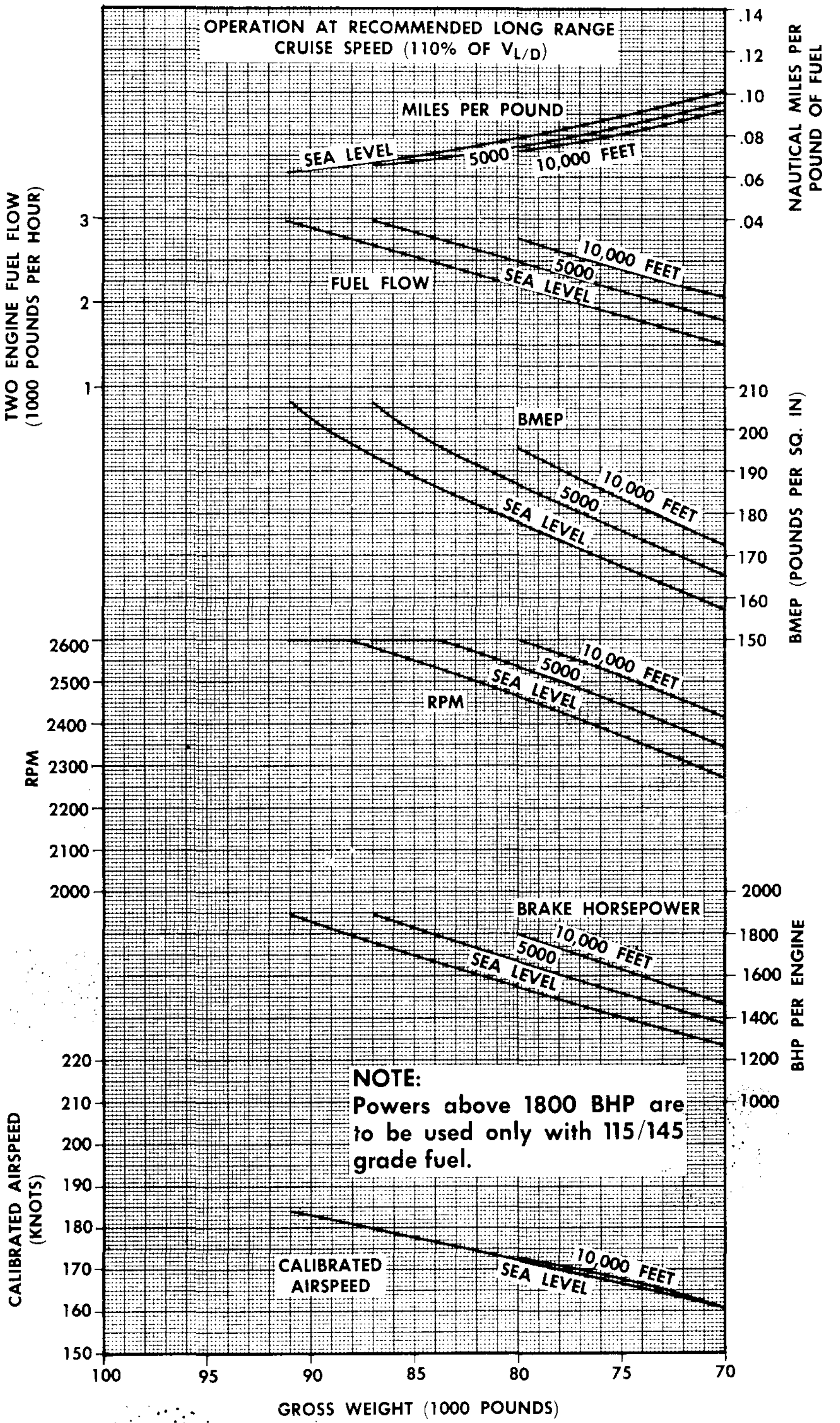


Figure A5-23. Two-Engine Long Range Summary

FOUR-ENGINE MAXIMUM ENDURANCE POWER CONDITIONS
STANDARD DAY

MODEL: C-118A
DATA AS OF: 2-15-59
DATA BASIS: LEAN—FLIGHT TEST
RICH—CALCULATED DATA

ENGINE(S): R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/13

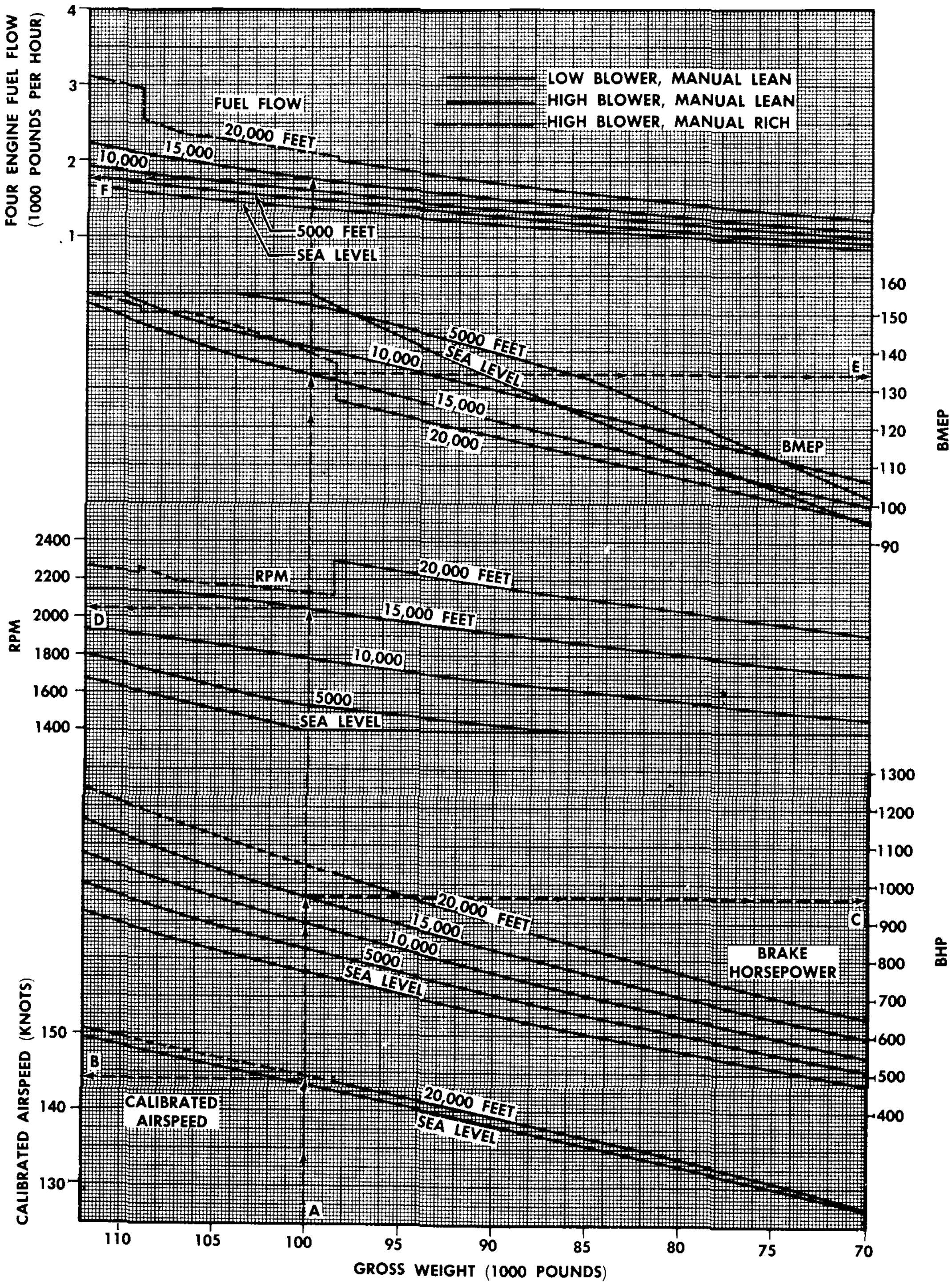


Figure A5-24. Four-Engine Maximum Edurance Power Conditions

THREE-ENGINE MAXIMUM ENDURANCE POWER CONDITIONS
STANDARD DAY

MODEL: C-118A
DATA AS OF: 1-15-59
DATA BASIS: LEAN—FLIGHT TEST
RICH—CALCULATED DATA

ENGINE(S): R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

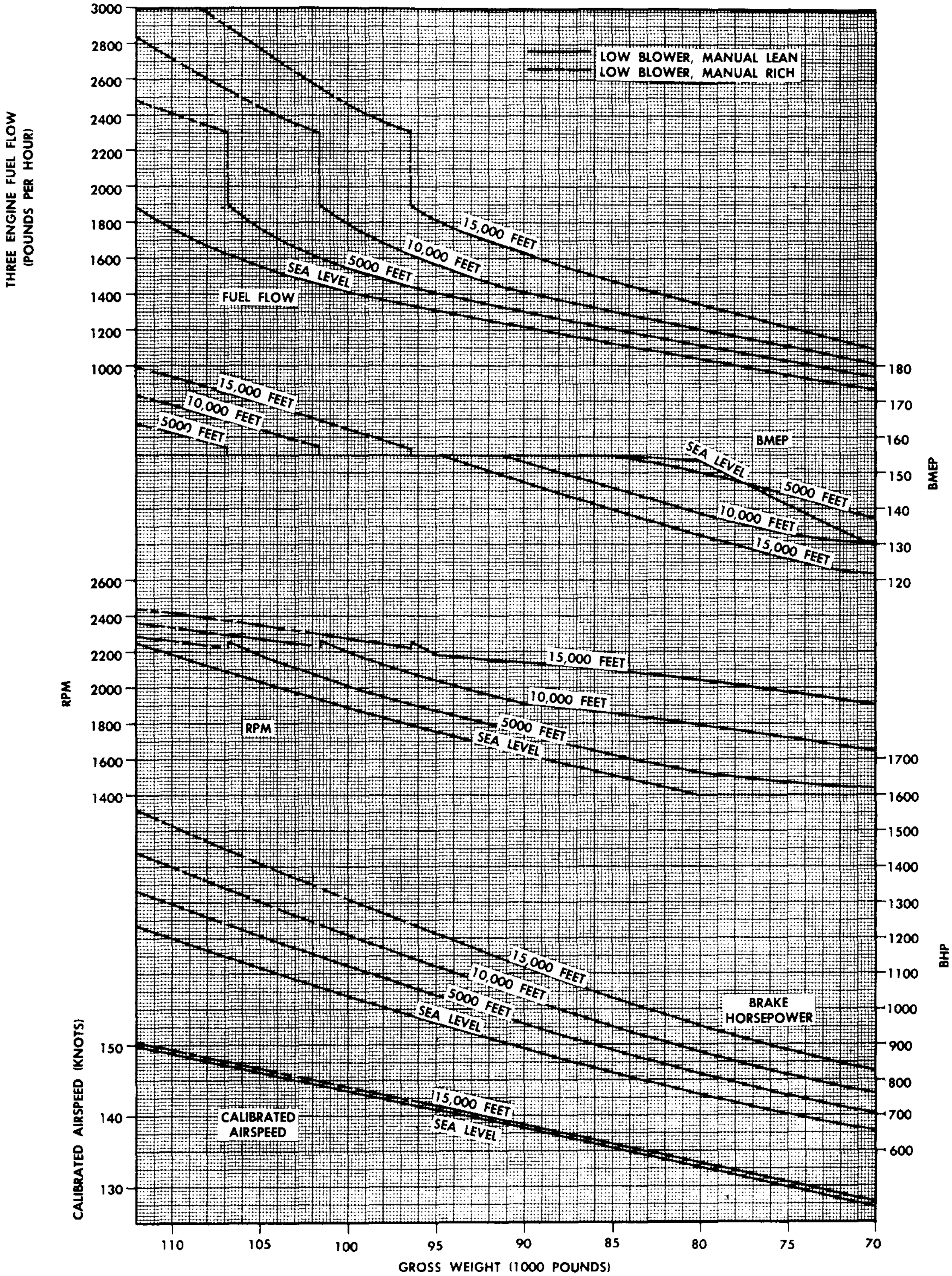


Figure A5-25. Three-Engine Maximum Edurance Power Condition

TWO-ENGINE MAXIMUM ENDURANCE POWER CONDITIONS

STANDARD DAY

MODEL: C-118A
DATA AS OF: 10-15-64
DATA BASIS: LEAN — FLIGHT TEST
RICH — CALCULATED DATA

ENGINE(S): R2800-52W

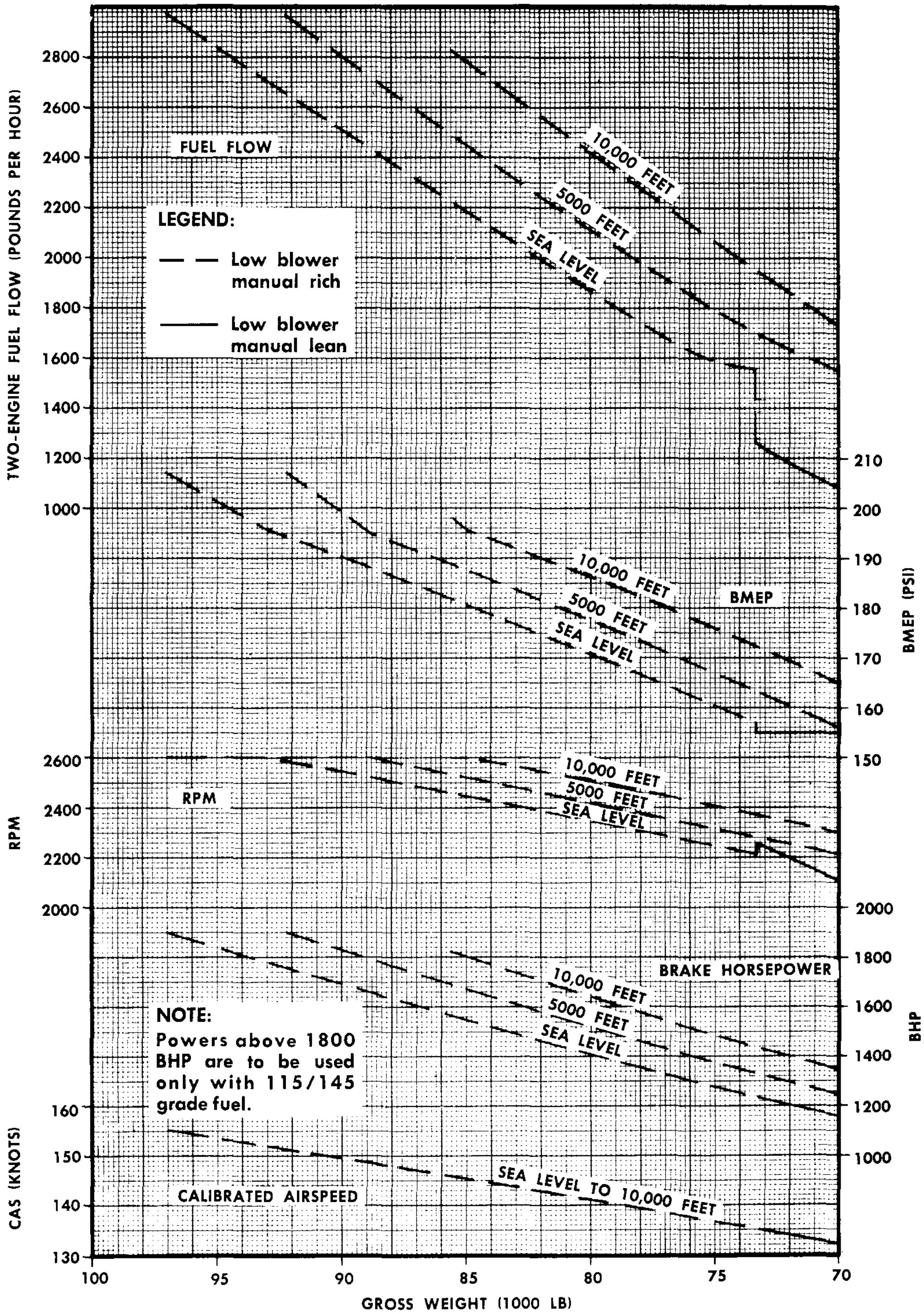


Figure A5-26. Two-Engine Maximum Endurance Power Conditions

MODEL: C-118A
DATA AS OF: 10-15-64
DATA BASIS: FLIGHT TEST

LEVEL FLIGHT PERFORMANCE
FOUR-ENGINE AND THREE-ENGINE OPERATION

ENGINES: R2800-52W

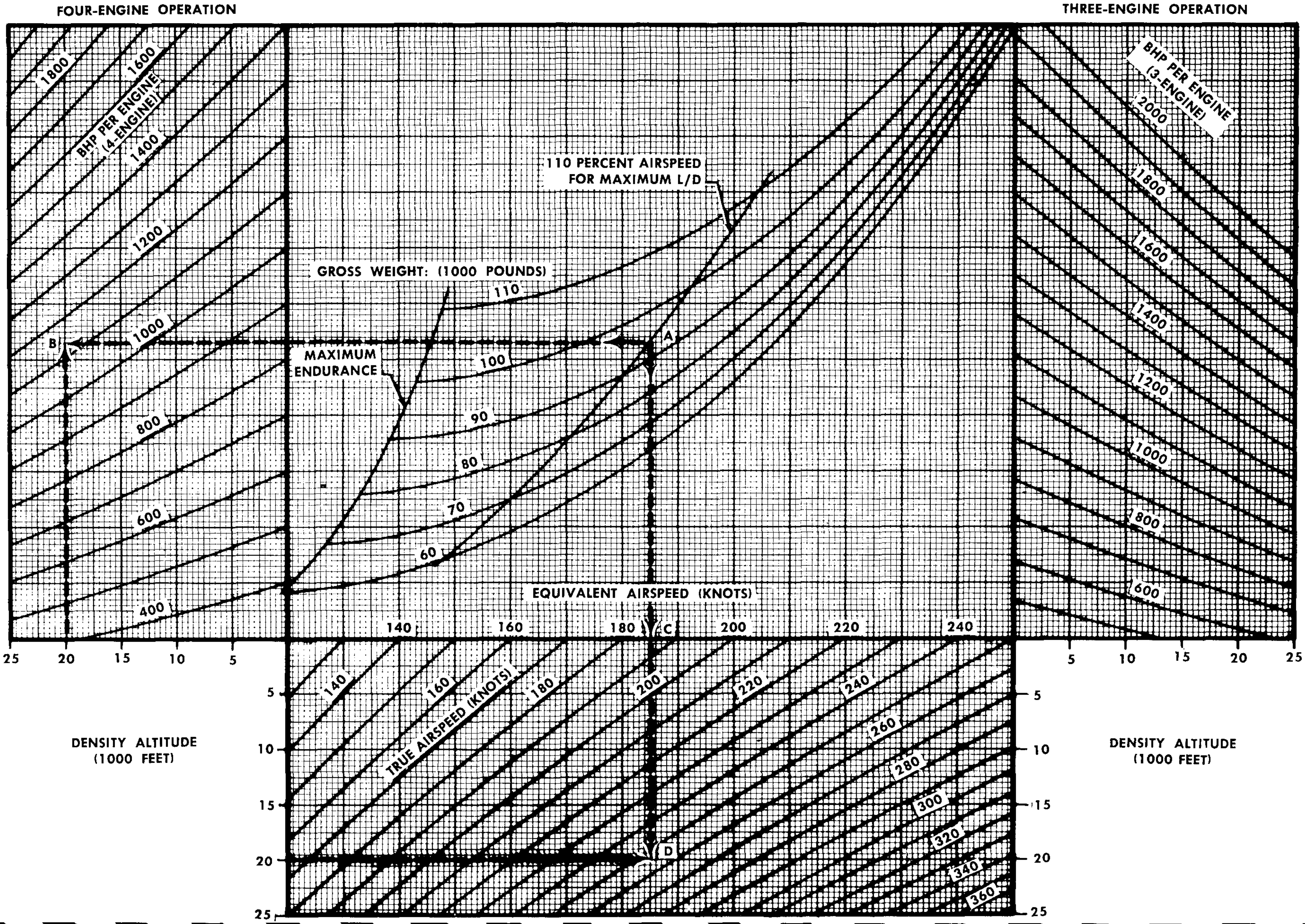


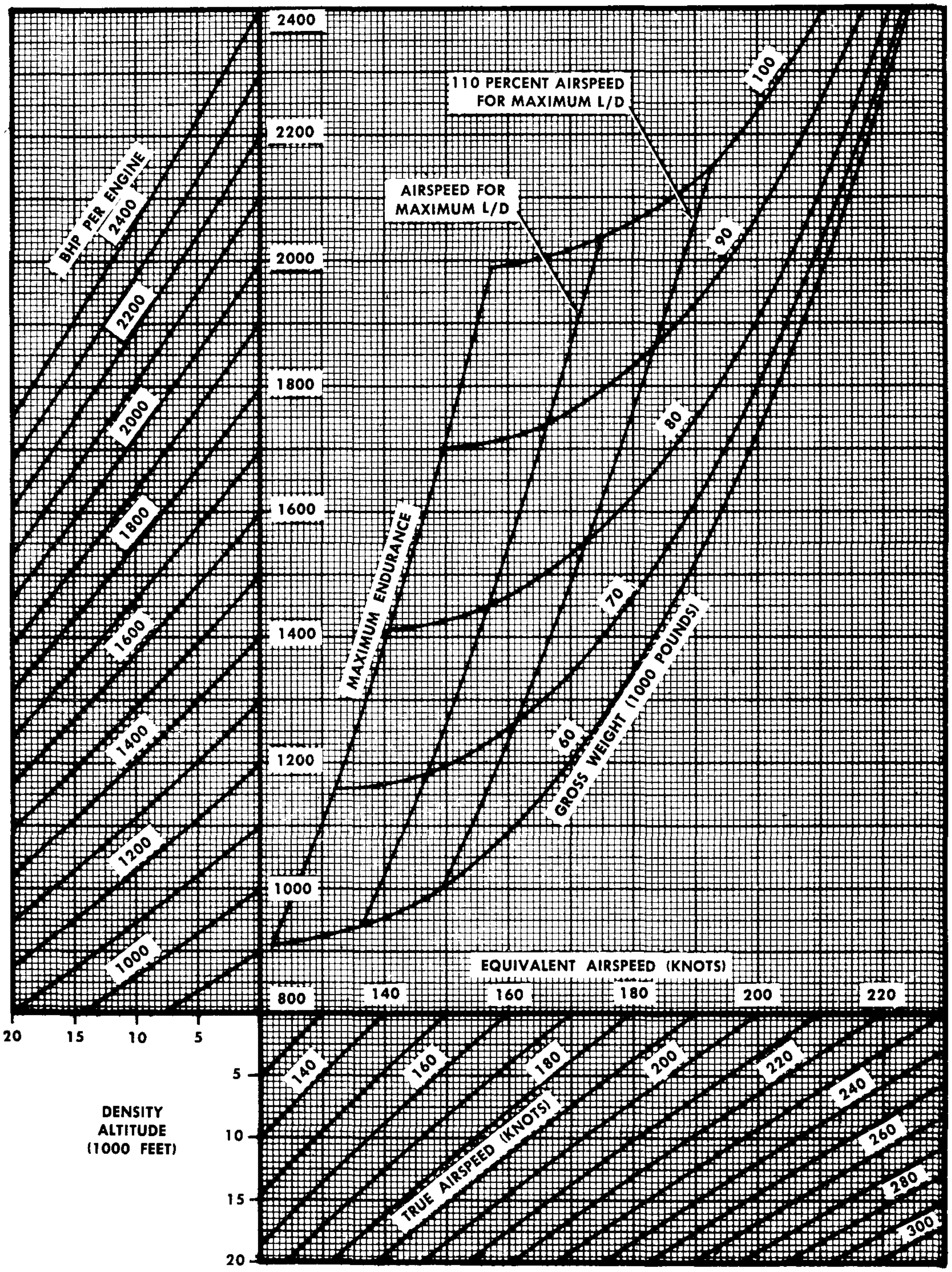
Figure A5-27. Level Flight Performance - Four-Engine and Three-Engine Operation

APPROXIMATE TWO-ENGINE LEVEL FLIGHT PERFORMANCE
TWO ENGINES INOPERATIVE ON ONE SIDE
INOPERATIVE PROPELLERS FEATHERED

COWL FLAPS ON OPERATING ENGINES OPEN (+3 DEGREES)
COWL FLAPS ON INOPERATIVE ENGINES CLOSED (−4 DEGREES)

MODEL: C-118A
DATA AS OF: 10-15-64
DATA BASIS: FLIGHT TEST

ENGINE(S): (4) R2800-52W



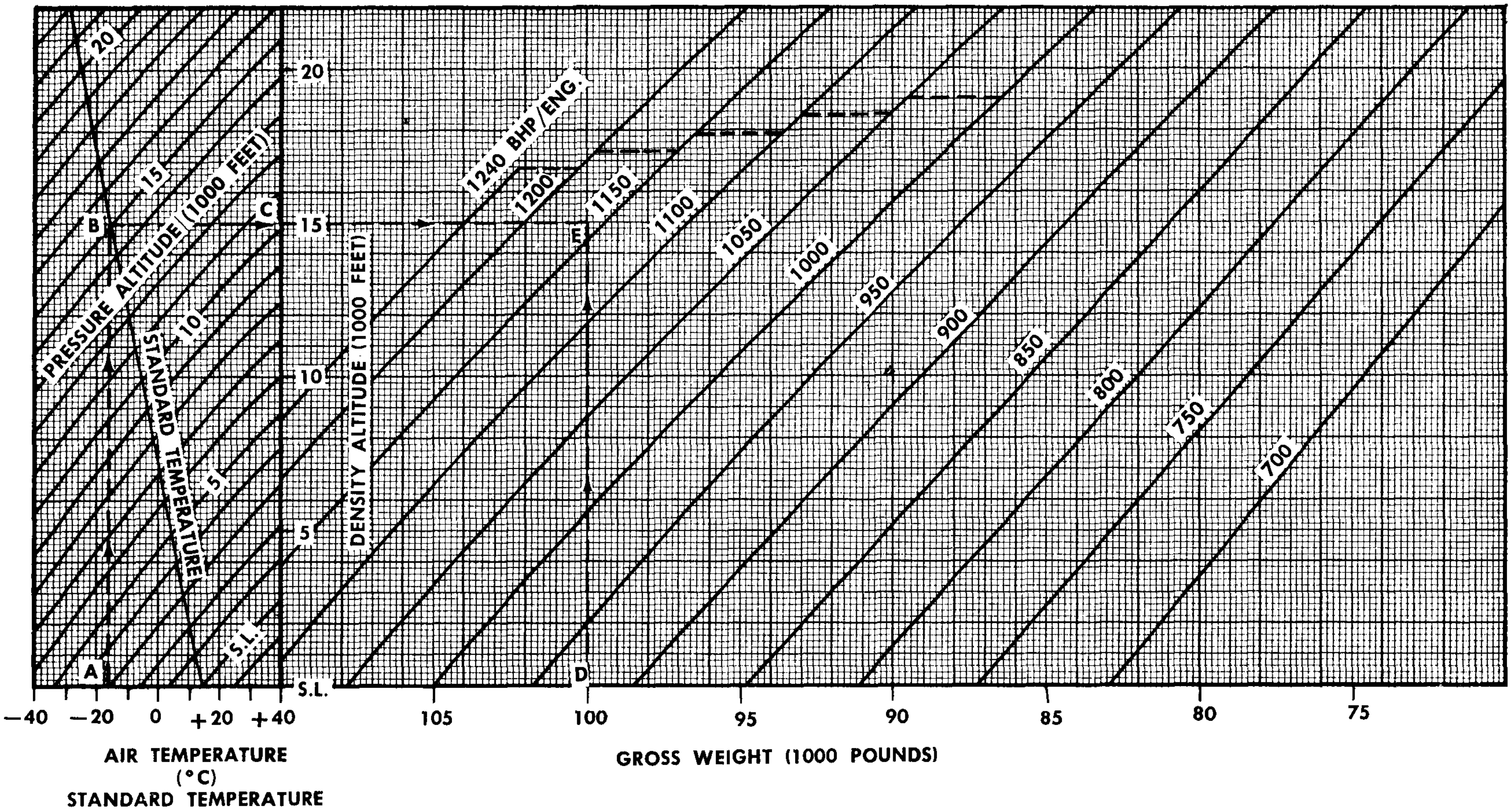
NOTE:
When using chart brake horsepower the torquemeter brake horsepower per engine should be taken as the chart brake horsepower per engine minus power required for cabin super-charging which is an average of 17.5 BHP per engine for this two-engine operation.

Figure A5-28. Approximate Two-Engine Level Flight Performance

POWER REQUIRED TO MAINTAIN 1.1V L/D
ALL ENGINES OPERATING

MODEL: C-118A
DATA AS OF: 2-15-59
BASED ON: FLIGHT TEST DATA

ENGINES: (4) R2800-52W



NOTE:
Flight at altitudes above dotted lines require the use of high blowers.

Figure A5-29. Power Required to Maintain $1.1V_{L/D}$

FOUR-ENGINE RANGE PREDICTION – DISTANCE
RECOMMENDED LONG RANGE CRUISE SPEED
NO WIND

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

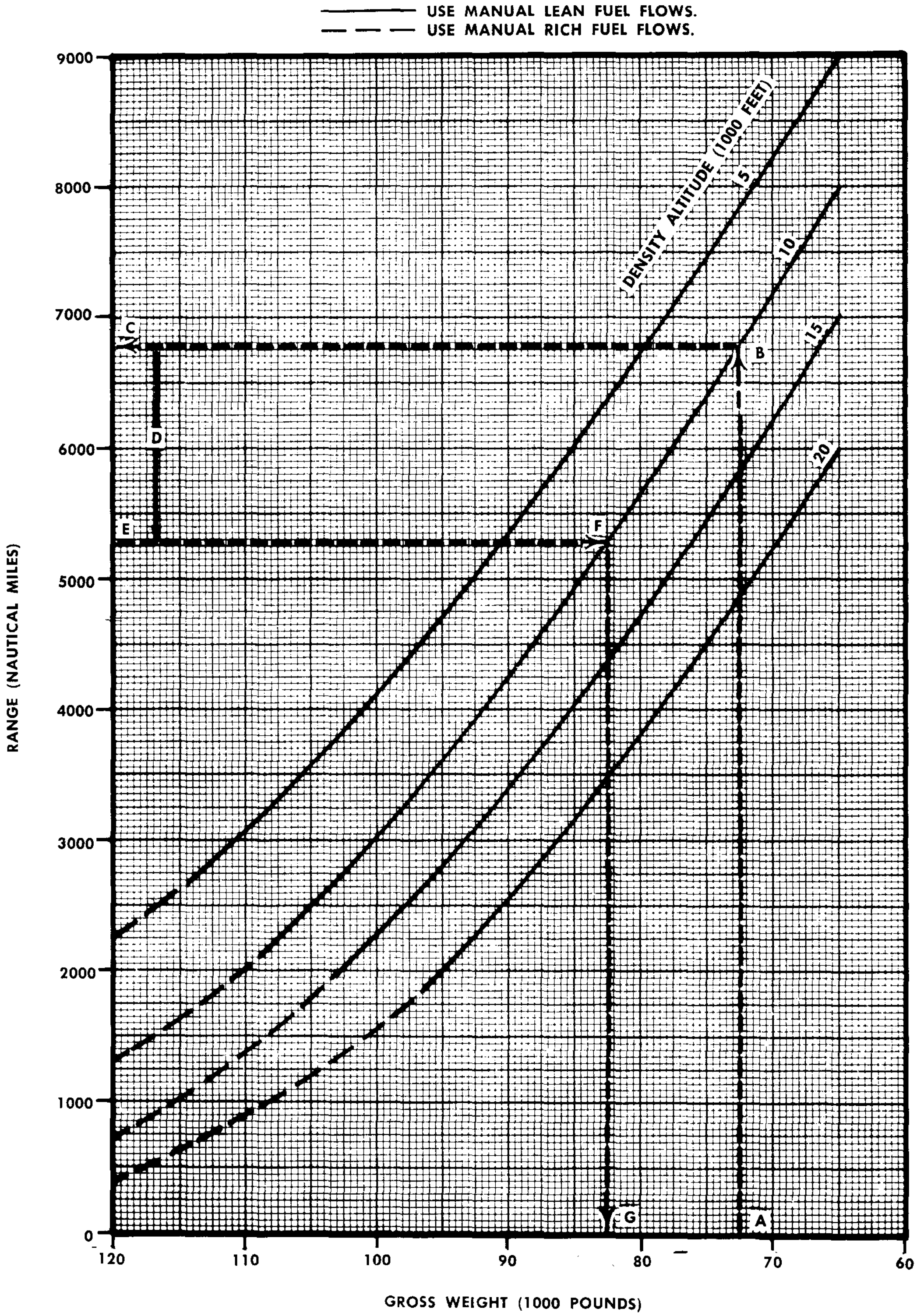


Figure A5-30. Four-Engine Range Prediction - Distance

FOUR-ENGINE RANGE PREDICTION – TIME

RECOMMENDED LONG RANGE CRUISE SPEED
NO WIND

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

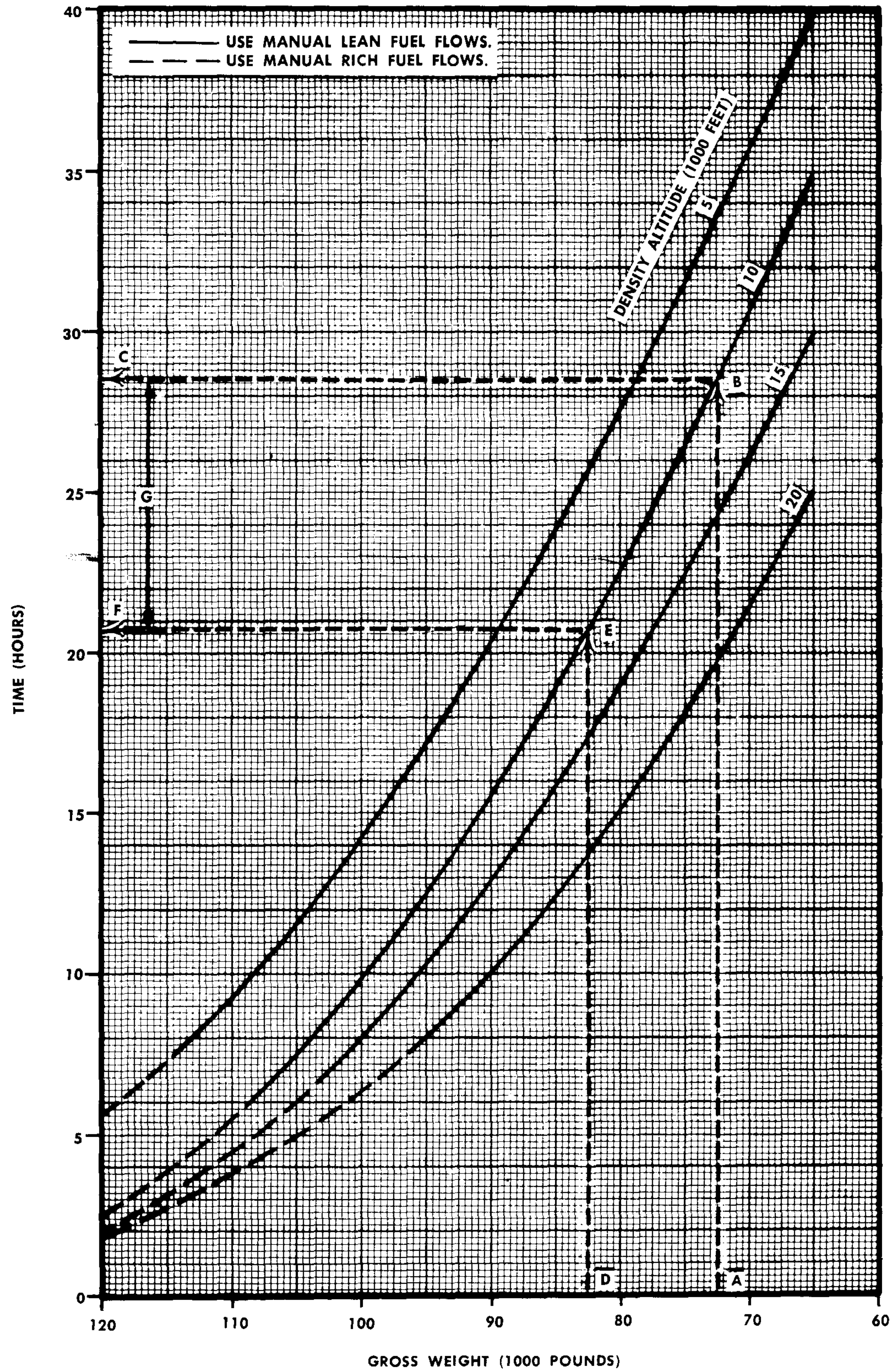


Figure A5-31. Four-Engine Range Prediction - Time

THREE-ENGINE RANGE PREDICTION – DISTANCE
RECOMMENDED LONG RANGE CRUISE SPEED
NO WIND

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

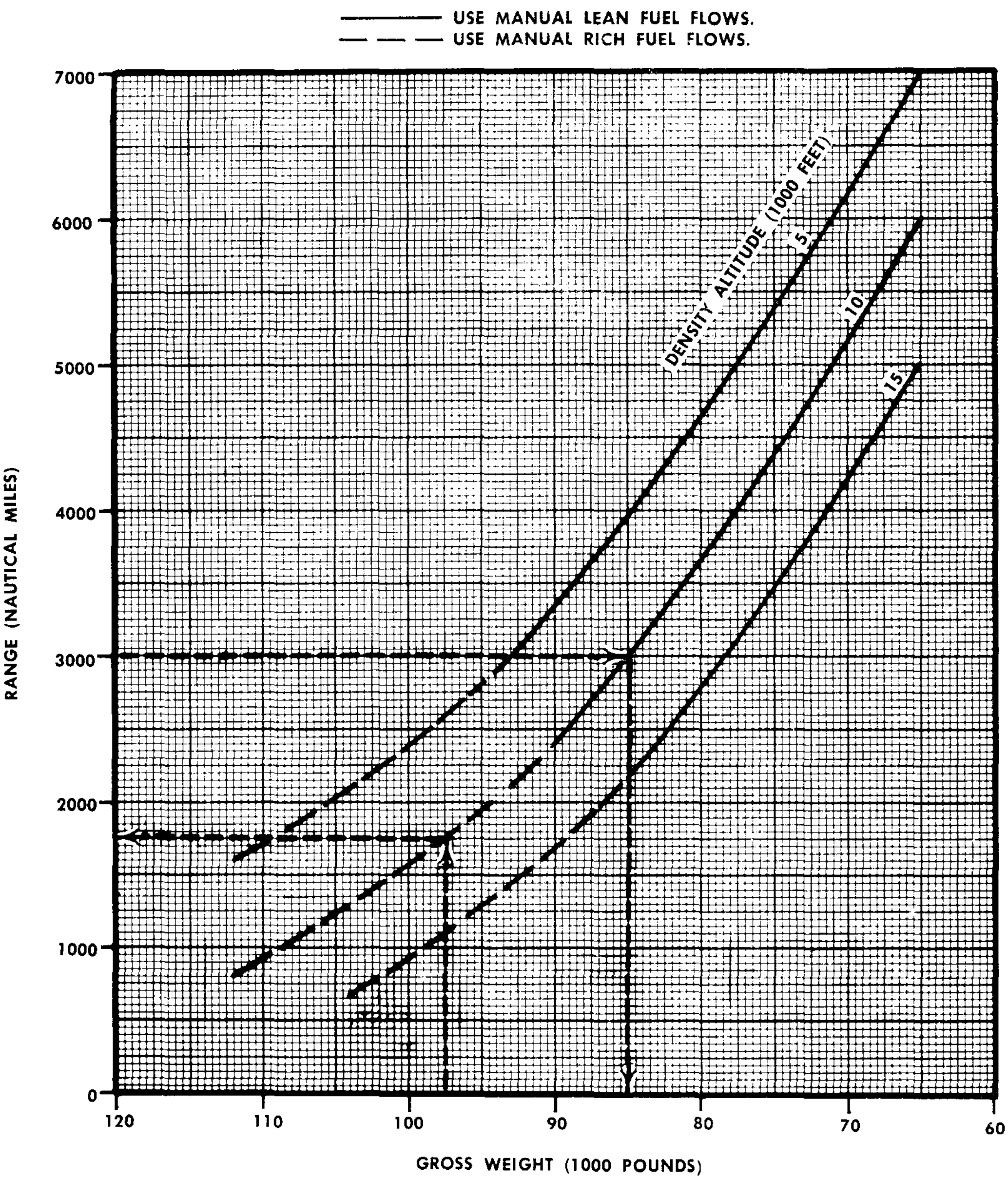


Figure A5-32. Three-Engine Range Prediction - Distance

THREE-ENGINE RANGE PREDICTION – TIME
RECOMMENDED LONG RANGE CRUISE SPEED
NO WIND

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

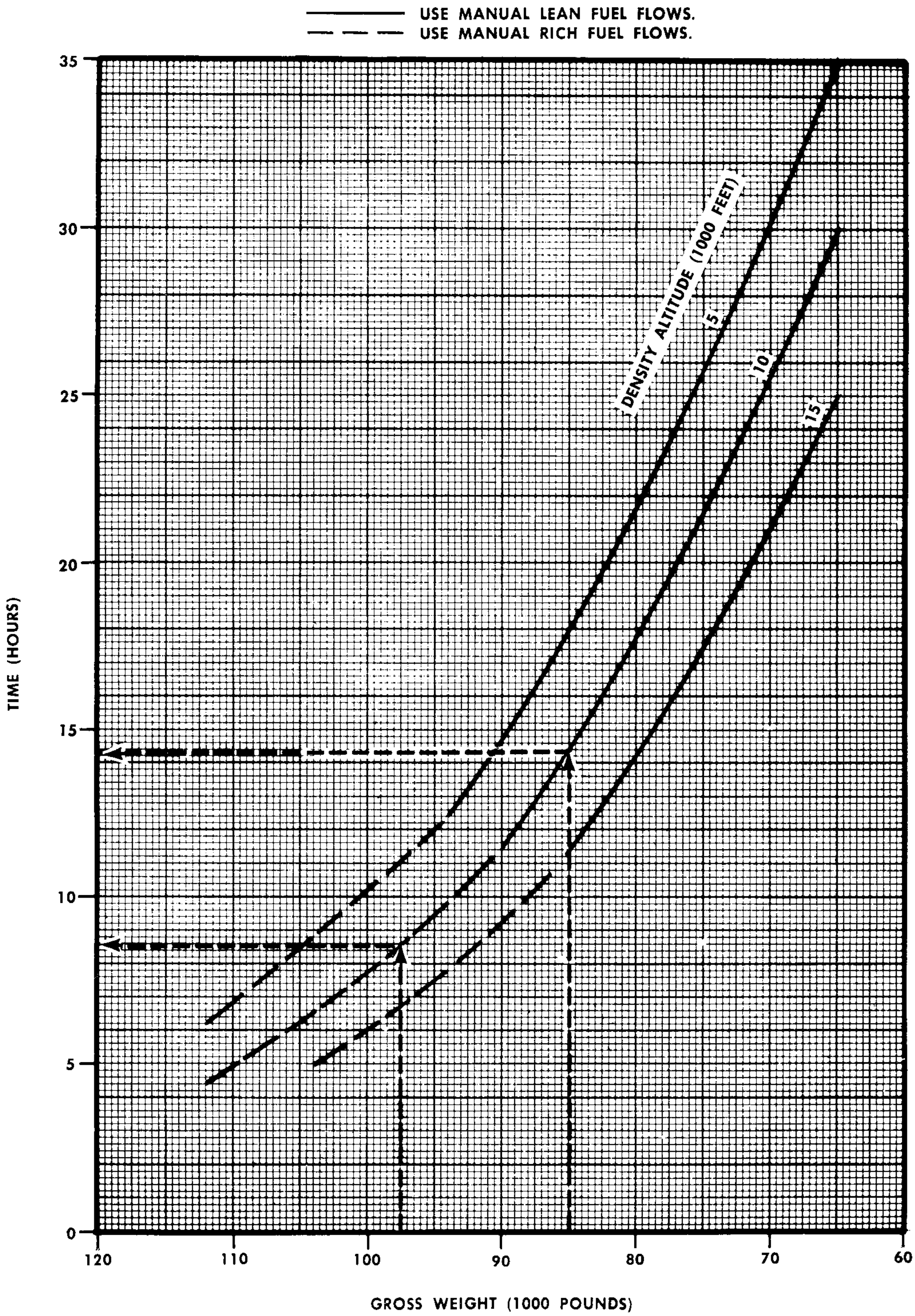


Figure A5-33. Three-Engine Range Prediction - Time

TWO-ENGINE RANGE PREDICTION – DISTANCE

RECOMMENDED LONG RANGE CRUISE SPEED

NO WIND

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

USE MANUAL RICH FUEL FLOWS.

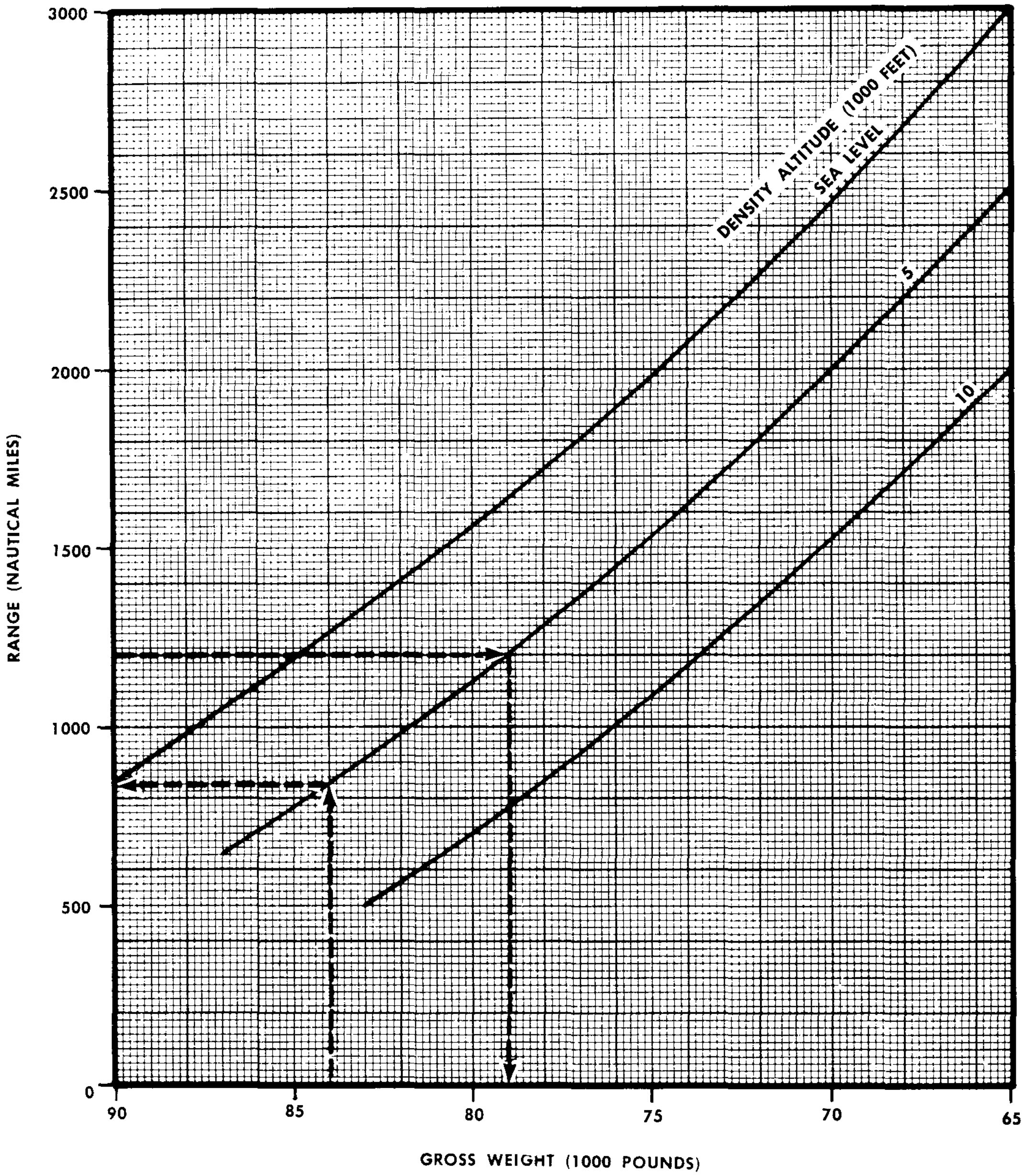


Figure A5-34. Two-Engine Range Prediction - Distance

TWO-ENGINE RANGE PREDICTION – TIME
RECOMMENDED LONG RANGE CRUISE SPEED
NO WIND

MODEL: C-118A
DATA AS OF: 6-15-62
DATA BASIS: FLIGHT TEST

ENGINES: (4) R2800-52W
FUEL GRADE: 115/145
ALTERNATE FUEL GRADE: 100/130

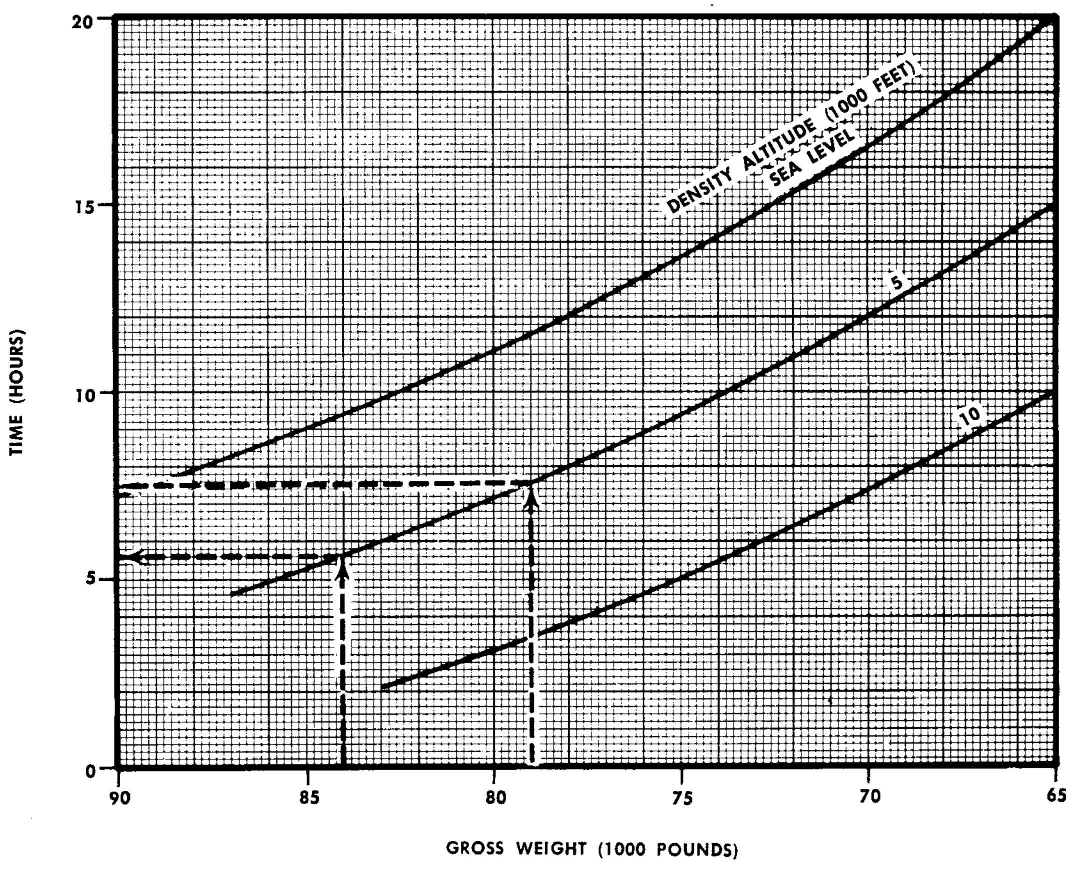


Figure A5-35. Two-Engine Range Prediction - Time