part 3—TAKEOFF

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Page numbers in bold face type denote illustrations.

SCOPE.

The data in this part of the Appendix presents normal and emergency takeoff performance for various values of altitude, gross weight, wind, slope, and runway surface condition. To standardize the use of the charts, takeoff and thrust factors are employed as the primary values throughout. Maximum power prediction charts are presented first in order that the factors can be determined. The power prediction charts are followed by charts used for takeoff flight planning. The scope of the data is such that a solution may be extracted for any peculiar case which arises. This is illustrated by the sample problems included in the text material.

BASIS FOR TAKEOFF PERFORMANCE.

Takeoff distances shown in this part are based on flight tests and reflect performance under standard and non-standard-day conditions of temperature and power. Corrections are included to account for the effects of wind, runway slope, and surface conditions.

TEMPERATURE EFFECT.

Air temperature affects air density and power available, and consequently influences takeoff performance. For a particular field elevation, takeoff performance will improve with lower-than-standard air temperature; that is, the aircraft can take off at a lower true airspeed and the takeoff distance will be shorter. At temperatures higher than standard the converse is true: the true airspeed necessary for takeoff will be higher and the takeoff distances will be longer. It is also possible that higher-than-standard temperatures may prevent the use of standard-day power because of manifold pressure limitations, thus decreasing the ability of the aircraft to accelerate, and increasing takeoff distance still more.

EFFECT OF HUMIDITY.

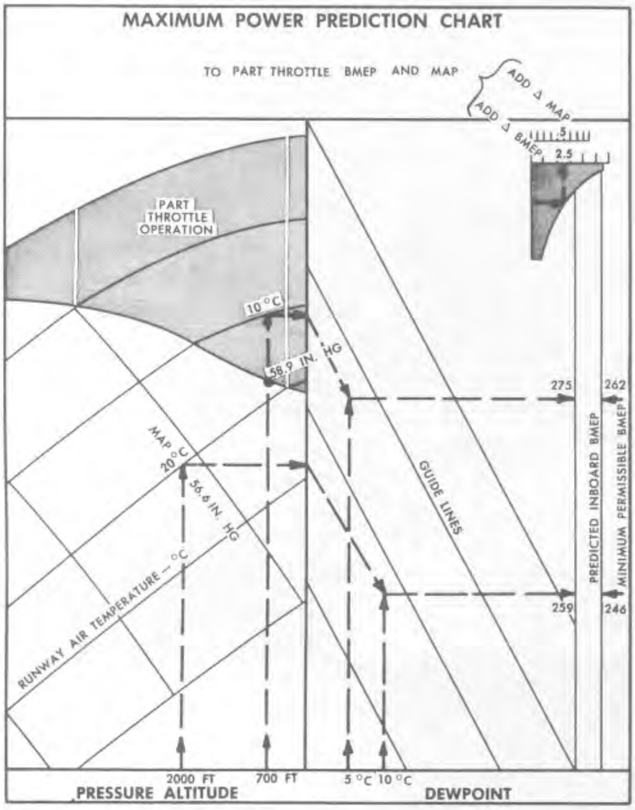
The existence of water vapor in the air affects the maximum power available for a given manifold pressure and temperature. If water vapor is present, the available power is reduced. This power loss occurs because a portion of the oxygen necessary for combustion in the cylinder is displaced by water vapor. This results in an increasingly rich mixture. The thermal efficiency of the engine is decreased, less power is developed, and longer takeoff distances result. Power loss due to excessive water vapor cannot be regained if operating at full throttle. However, power loss due to humidity may be partially regained in the part-throttle region. This is possible through an allowable increase in the limit MAP.

PREDICTION OF MAXIMUM POWER AVAILABLE.

The maximum power prediction charts are presented in figures A3-1 through A3-5 and are divided into specific altitude segments. The charts show the power that can be expected from a properly functioning engine with ram effect. Lower power readings indicate a sub-standard engine condition.

The general charts, figures A3-2, -3, -4, and -5, have been divided into two parts. The left side of the chart is used for the prediction of MAP and BMEP without correction for power loss due to humidity. A shaded area crosses the upper portion of figure A3-2 to define part-throttle operation. It should be noted that chart entry is with runway air temperature. Should it be required that the ram scoops be closed for the takeoff, enter the chart with a runway air temperature approximately 3°C higher than indicated runway temperatures.

Whenever the intersection of the runway air temperature and the pressure altitude lines falls within the shaded area, the insert chart (also shaded) must be used, which permits a correction limit MAP and BMEP for given humidity conditions. The zero humidity MAP limit is allowed to increase twice the vapor pressure, but not to exceed a maximum of 1 inch Hg. (Refer to Part 2.)' The power loss due to humidity is shown on the right side of the chart. Two BMEP scales are shown on the right vertical axis; one scale is read to obtain predicted BMEP, and the other to obtain the minimum permissible BMEP (95 percent predicted BMEP). (Normally, the minimum permissible BMEP will be used to forecast takeoff performance.) The following examples of chart usage are shown for two cases, the first for full-throttle and the second for part-throttle operation, using figure A3-2.



EXAMPLE 1—FULL THROTTLE.

Conditions.

- Field elevation pressure altitude—2000 ft
- Runway temperature—20°C
- Dewpoint temperature—10°C

A full-throttle condition exists when the intersection of runway air temperature and pressure altitude lines is below the shaded area. Enter the left side of the chart at 2000 ft and proceed vertically until reaching a runway temperature of 20°C. Read MAP of 56.6 in. Hg. Proceed horizontally to the right side of the chart and follow the guide line until it intersects with the given dewpoint (10°C). Read the predicted and minimum permissible BMEP of 259 and 246 from the right-hand scales.

EXAMPLE 2—PART THROTTLE.

Conditions.

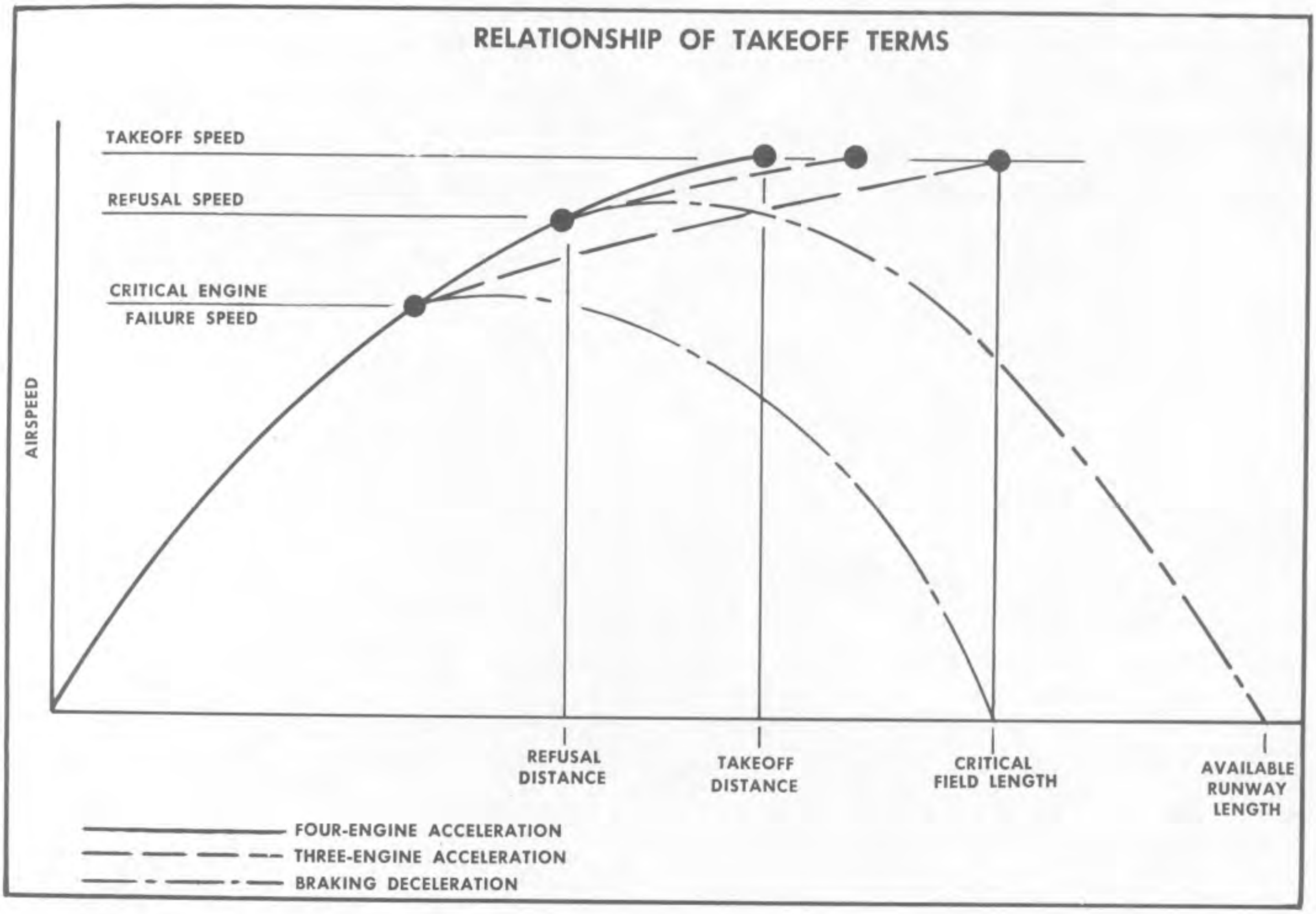
- Field elevation pressure altitude—700 ft
- Runway air temperature—10°C
- Dewpoint temperature—5°C

A part-throttle condition exists when the intersection falls within the shaded area. Enter the left side of the chart at the pressure altitude (700 ft) and proceed vertically until intersecting a runway air temperature of 10°C. In this case the intersection falls within the shaded area. At this intersection read the MAP of 58.9 in. Hg. Move horizontally to the right side of the chart and follow the humidity guide line to its intersection with the dewpoint temperature line and read the predicted and minimum permissible BMEP of 275 and 262 on the right vertical scales. Since the intersection of runway temperature line and pressure altitude line was within the shaded area, enter the insert chart at the given dew point and proceed horizontally to its intersection with the guide line; move up and read the ΔMAP and BMEP. Add these values to those obtained previously. Therefore, the expected MAP is 58.9 + 0.5, or 59.4 and the minimum permissible BMEP is 262 + 2.5, or 264.5.

TAKEOFF CRITERIA DEFINITIONS.

The following definitions are based on Specification MIL-M-7700A and are supplied for information purposes. Performance data in this appendix are in agreement with these definitions.

Refusal Speed—Maximum speed to which the aircraft can accelerate and then stop in the length of runway remaining.



Refusal Distance—The distance required to accelerate to the refusal speed.

Critical Airspeed for Engine Failure—The airspeed from which the aircraft may be decelerated to a stop or may accelerate and take off with three engines operating.

Critical Field Length—The total length of runway required to accelerate on all engines to the critical airspeed for engine failure, experience an engine failure, then continue to take off or stop.

Acceleration Check Distance—Distance from start of takeoff to an acceleration checkpoint. The checkpoint will never be less than 500 feet nor more than 1500 feet prior to the refusal distance.

Acceleration Check Speed—Minimum speed that is allowable at the acceleration check point.

Takeoff Speed—Speed at which the main gear leaves the ground or lifts off.

Takeoff Distance—Ground run in feet from brake release to takeoff speed.

TAKEOFF AND THRUST FACTOR.

The aerodynamic characteristics of an aircraft affect the takeoff ground run and climbout in different degrees. Due to this difference, a takeoff factor and a thrust factor are employed in this section. The takeoff factor is used on all charts where a climbout is not required, while the thrust factor is used on all charts involving climbs. Once the predicted BMEP is determined, enter the takeoff factor chart (figure A3-7) at the minimum permissible BMEP. Proceed vertically to the density altitude and read the takeoff factor on the vertical scale. Sheet 1 of figure A3-7 is for low blower while sheet 2 is for high blower. The choice of blowers can be obtained by finding the predicted BMEP's for low and high blower from the maximum power prediction charts. Next, enter the corresponding takeoff factor chart and determine the takeoff factors. The lower takeoff factor will result in the best takeoff performance. However, if both factors are equal, then the three-engine rate of climb charts should be referred to in order to determine the best climb performance. With the known takeoff factor, enter the thrust factor chart (figure A3-8) at the takeoff factor and proceed to the density altitude. Read the corresponding thrust factor on the horizontal scale.

APPLICATION OF WINDS TO TAKEOFF AND LANDING.

WIND 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.
Crosswind	Effective wind across the runway, determined from the steady wind value plus the gust increment.
Tailwind	Effective wind parallel to the runway, determined from the steady wind value plus the gust increment.

WIND DIRECTION, VELOCITY, AND ACCOUNTABILITY.

The possibility exists that wind direction and velocity will vary over various portions of the airfield. Likewise, wind shear may result in wind changes during climbout and landings. Therefore, within instrument limitations, winds are usually valid at the point of measurement.

Because of these variables, it is recommended that 50 percent of the headwind component and 150 percent of the tailwind component be applied. Use 100 percent of the steady headwinds or tailwind components for checking acceleration. However, if experience has shown that reported winds are those actually experienced at the runway in question, they may be used directly.

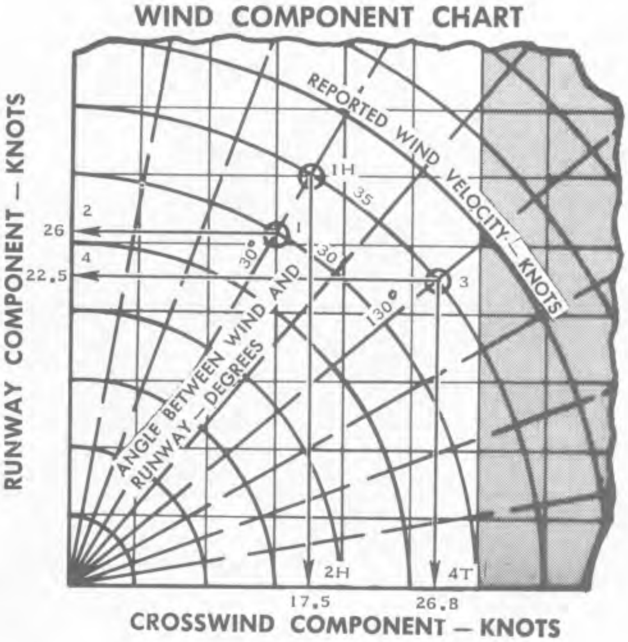
Headwind benefits should be accepted as a safety margin increase and should be applied only when mission requirements warrant its use.

During gusty conditions always increase the takeoff, threshold, and landing speed by the full gust increment, but not to exceed 10 knots. The erratic characteristics of gusts, as to magnitude and direction of the wind, may result in a high relative airspeed reading, which may result in a dangerous situation, should the wind change direction or decay.

The application of the preceding rules to winds are summarized on sheet 1 of figure A3-8.

WIND COMPONENT CHART.

The wind component chart, sheet 2 of figure A3-8, is used to determine the wind component parallel and across (crosswind) the runway. Wind angles of zero to 90 degrees for headwinds and 90 to 180 degrees for tailwinds for wind velocities of 60 knots are included. Takeoffs with crosswind components greater than 30 knots are not recommended. Takeoff speeds are increased only for gust increments but not to exceed 10 knots.



EXAMPLE 1.

- Takeoff speed 120 knots IAS
- Runway 07 (70 degrees)
- Wind—from 100 degrees at 30-knots
- Gusts to 35 knots
- Applied runway wind angle—30 degrees (100 − 70)

From sheet 2 of figure A3-8:

- Runway component—26 knots (1-2) headwind
- Crosswind component—17.5 knots (include gust, 1H, 2H)

Because of the 5-knot gust increment, increase takeoff speed to 125 knots IAS.

EXAMPLE 2.

- o Takeoff speed – 120 knots IAS
- o Runway 25 (250-degrees)
- o Wind – from 020 at 20 knots
- o Gusts to 35-knots
- o Runway wind angle – 230 degrees (250 – 20)

Whenever the runway angle exceeds 180 degrees, subtract the value from 360-degrees to use the Wind Component Chart.

- o Applied runway wind angle – 130-degrees (360 – 230)

From sheet 2 of figure A3-9:

- o Runway Component – 22.5 knots (3-4) tailwind
- o Crosswind Component – 26.8 knots (3-4T)

Takeoff speed is increased to 130 knots IAS as per sheet 1 of figure A3-9.

SLOPE.

Runway slope must be considered in takeoff planning. Takeoff and landing performance charts include 2-percent correction grids. Figure A3-22 provides correction grids for runway slopes up to 8-percent.

NORMAL TAKEOFF PERFORMANCE.

Four-engine ground run distances to take off, using normal takeoff procedures, are shown in figure A3-10. An allowance of 200 ft should be made in takeoff computations. Correction grids are supplied which account for the effects of true wind existing at the runway, and runway slope. The distances shown apply to operation from dry, hard-surfaced runways using 60 percent (TAKEOFF) wing flap setting and maximum power. The speed schedule recommended for normal takeoffs is 1.15 times the zero thrust stall speed. Normal recommended climbout speeds are 5 to 7 knots faster. Their use places the aircraft in an advantageous position should an emergency arise.

It is most important that the nosewheel be kept on or close to the runway until approximately 10 knots below the takeoff speed. At this point, start a smooth rotation to takeoff attitude, so that the aircraft leaves the ground at the takeoff speed. This procedure results in maximum acceleration being achieved during the run and minimizes the possibility of overshooting the takeoff speed prior to leaving the ground. To reduce aerodynamic drag the landing gear should be retracted as quickly as possible after leaving the ground.

References to 135.4 and 137.5 on takeoff Data Charts refer to possible mandatory use of reverse for stopping (135.4) and to the landing gear strut loading limitation (137.5).

EMERGENCY TAKEOFF PERFORMANCE.

Although the probability of experiencing an engine or propeller failure during takeoff is small, the decrease in performance resulting from the drop in power available is sufficiently important to warrant consideration. Refusal speeds, critical airspeeds for engine failure, critical field lengths, and maximum power climb performance should be determined prior to each takeoff as a standard practice. When these two are known, two general rules can be applied which are summarized as follows:

1. The takeoff should be aborted and the aircraft brought to a stop if a takeoff emergency develops before or upon reaching the critical airspeed for engine failure.
2. The takeoff should be continued and the aircraft flown out on three engines if the emergency develops after the refusal speed is reached.

The critical airspeed for engine failure will be equal to or less than the refusal speed; it depends on runway length and takeoff conditions. The decision to reject or continue a takeoff is optional when an emergency occurs between the critical speed and refusal speed; however, a stop is recommended

If the takeoff is continued and a climbout is made on three engines, a climb speed schedule of 1.15 times the zero-thrust stall speed should be held until all obstacles are cleared. Unless otherwise specified, this speed schedule is used in three-engine flight presentations. Do not accelerate during a three-engine climb until above the obstacles. If failure occurs during climbout at a speed greater than 1.15 V_s, hold that speed until clear of obstacles or decelerate to 1.15 V_s.

MINIMUM CONTROL SPEED.

Minimum ground control speed (V_{MCG}) is the lowest airspeed for engine failure where directional control can be maintained with aerodynamic controls. Minimum ground control speed is 84 knots IAS (No. 2 static). A stop must be made if engine failure occurs before this speed.

Minimum air control speed (V_{MCG}) is the lowest airspeed where constant heading can be maintained with one outboard engine inoperative and the propeller windmilling at low pitch stop, maximum power on the operative engines, 60 percent wing flaps, gear up or down, and a bank angle not exceeding 5 degrees. This speed is 91 knots IAS.

VELOCITY DURING GROUND RUN.

Acceleration check speeds are obtained from the Velocity During Ground Run chart (figure A3-11). It is preferable to determine an acceleration check for known distances (runway markers). This is found by entering the chart at the takeoff gross weight on the horizontal scale and the ground run distance (corrected for wind and slope) on the vertical scale. This intersection determines the normal acceleration guide line and is used to establish aircraft velocities and time at any value of runway distance.

It is emphasized that determination of the normal acceleration line is made with a takeoff distance that is corrected for full wind and slope effect.

The first acceleration check is usually made at a runway marker 1000 feet or less below the refusal distance. With poor visibility or on unmarked runways, acceleration checks may be made by relating speed to time.

With the determined normal acceleration line, enter with a check distance and read speed or enter with a speed and read time. Time data are calculated. Should takeoff speed be increased, enter chart with the new speed, intersect the predetermined acceleration guide line and read the increased takeoff distance.

CRITICAL FIELD LENGTH AND CRITICAL AIRSPEED.

The critical field length with engine failure for zero obstacle clearance without and with reverse thrust may be determined from figures A3-12 and A3-15, respectively. These charts represent distances that balance a takeoff run with an engine failure and takeoff, against the distance to accelerate to the engine failure speed and stop. The critical airspeed for engine failure may be determined from the respective refusal speed charts, figures A3-13 and -16.

REFUSAL SPEED.

The refusal speed is the maximum speed to which the aircraft can accelerate and then stop within the available runway. This chart, figure A3-13, is based on a four-engine acceleration to a speed, a 3-second reaction time, and a hard wheel braking stop without using reverse thrust. Refusal speeds which include the effects of symmetrical 2-engine reverse thrust with simultaneous hard wheel braking are shown in figure A3-16. If the takeoff gross weight is runway limited, the refusal speed is the critical engine failure speed. If the corrected refusal speed falls at or above the takeoff speed, takeoff speed will be the refusal speed.

FOUR- AND THREE-ENGINE CLIMBOUT FLIGHT PATHS.

The four-engine climbout flight path curves are shown in figure A3-14, sheets 1 and 2. These charts are used to determine the horizontal distance required to clear an obstacle during a climbout. Enter sheet 1 with the thrust factor, move horizontally to the gross weight, and down to a climb performance factor. Enter sheet 2 with this factor and an obstacle height and read the ground distance from point of takeoff. The three-engine climbout flight path charts, figure A3-14, sheets 1 and 3, are used in the same manner.

REFUSAL DISTANCE.

The refusal distance is the amount of runway required to accelerate on four engines to the refusal speed. This value is extracted from the Velocity During Ground Run chart. Enter figure A3-11 with the refusal speed and intersect the normal four-engine acceleration guide line. At this intersection read the refusal distance from the vertical scale.

REVERSE THRUST – REFUSAL SPEED.

Reverse thrust stopping distances have been incorporated into the Refusal Speed chart. Enter figure A3-15/A3-25 with the refusal speed. These distances assume simultaneous wheel brake and reverse thrust application. Variables that affect reverse thrust stopping distances at a specific takeoff factor include aircraft weight and velocity, rpm, and number of operating propellers. The inclusion of the specific effects of all these parameters would result in a complex chart. Simplification was accomplished by assuming a nominal stopping distance reduction. This results in reverse thrust stopping distances that are within aircraft capability when using normal pilot technique. The distances are applicable with symmetrical two-engine (approximately 2500 rpm), four-engine (approximately 2000 rpm), and symmetrical two-engine with gradual reverse thrust application to the third engine. Caution should be exercised in applying three-engine reverse thrust, as the aircraft may enter into an uncontrollable situation. It would be advisable to verify the calculated data by performing controlled accelerate and stop runs. Correlation of these results with chart data will define chart limitations that may be imposed prior to use in normal preflight planning.

EFFECT OF RUNWAY SURFACE CONDITIONS.

Stopping distance depends upon a tire-to-runway coefficient of friction which will vary with the condition of the runway surface. The condition of the runway surface 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 the 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 scales as a function of RCR.

Many airfields will continue to report braking action in accordance with ICAO documents. This is the "good," "medium," "poor" categorization of braking action on unusual runway surface condition. In order to relate this categorization 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

Also reported will be Runway Surface Covering (RSC) which will be the average runway surface covering given in depth and type, such as slush, water, or snow. 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 surface.

The retarding effect of slush and water puddles increases as the speed increases. However, the retarding effect will vary considerably with the varying slush and water depths expected on the runway as a result of runway use or contour. The retarding effect of slush and water puddles will decrease when the airplane reaches hydroplaning speed. Hydroplaning occurs because the pressure between the fluid on the runway and the tires increases as speed increases until the tires are entirely supported on top of the fluid. The speed at which this occurs is called hydroplaning speed. Because of the above effects, an acceleration check is not valid when measurable depth of runway surface covering are present. Therefore, extreme caution should be exercised throughout the takeoff run.

RUNWAY CONDITION READINGS (RCR).

RCR is a measure of the tire-to-runway friction coefficient. RCR is reported as a whole number varying from 4 to 26 and is used to determine the stopping capability for the particular runway surface condition.

RUNWAY SURFACE COVERING (RSC).

RSC is the average surface covering and is determined in depth to 1/10-inch and type, as listed below:

P	Patchy
WR	Wet Runway
SLR	Slush on Runway
LSR	Loose Snow on Runway
PSR	Packed Snow on Runway
IR	Ice on Runway

A typical report of runway condition could be SLR 05P, which would indicate slush on runway with an RCR of 05 and patchy condition.

THREE-ENGINE RATES OF CLIMB.

Three-engine rates of climb at takeoff speeds and TAKEOFF flaps (60%) are shown in figures A3-17 through A3-20 for maximum, METO, and alternate METO power. The chase-around on these charts illustrates their use.

TAKEOFF WEIGHT AS LIMITED BY RUNWAY SLOPE.

Under certain conditions it is possible to reach takeoff speed on three engines within a reasonable distance and still be unable to take off. This situation occurs when the runway slope (or gradient) is greater than the initial climb gradient of the aircraft with gear and TAKEOFF flaps (60%) extended. The maximum takeoff weight as limited by runway slope is shown in figure A3-21. The limit weight is that takeoff weight where the gear-down climb gradient is equal to the runway slope.

SLOPE EFFECT.

Figure A3-22 is included to modify aircraft performance for runway slopes to 8-percent. Correction grids are included for accelerate distance (takeoff), accelerate and stop distance (critical field length and available runway lengths), stopping distance, and refusal speed.

The performance data may be modified by either of two methods. Entry may be made at actual distance/speed at 2-percent that is read from a performance chart and corrected to some greater slope or at a zero slope distance/speed read from a performance chart and then corrected to the actual runway slope.

MINIMUM TAKEOFF DISTANCE.

Minimum ground run distance to takeoff is shown in figure A3-23. Takeoff speeds are zero-thrust stall speeds. The following example will illustrate the use of figure A3-23.

Conditions.

- Takeoff factor—3.25
- Takeoff weight—130,000 lb
- Corrected wind—20 knots, headwind
- Runway slope—1 percent uphill

Enter with the takeoff factor of 3.25 (1) and proceed horizontally to takeoff weight of 130,000 lb (2). Proceed vertically downward to baseline (3). Move parallel to headwind guide lines to 20 knots (4). Proceed vertically downward to the slope baseline (5); then, follow uphill slope guide lines to 1 percent (6). Continue vertically to (7) and read minimum ground run distance to takeoff of 2025 feet.

THREE-ENGINE FERRY CONFIGURATION TAKEOFF PERFORMANCE.

Occasions may arise when it becomes necessary to ferry an aircraft away from a base where engine or propeller repair facilities are not available. Figure A3-24 shows aircraft takeoff and climb-to-50-feet distances with the propeller of the inoperative engine feathered or removed. The rate-of-climb performance may be found in figures A3-17 and A3-18. The performance shown is applicable if the aircraft is operated with normal takeoff trim and TAKEOFF flaps (60%). Takeoff speed schedule used is 1.30 times the zero-thrust stall speed. Takeoff power should be applied to two symmetrical engines (No. 1 and 4 or No. 2 and 3). Gradual application of power to the asymmetrical engine as rudder effectiveness is gained ensures directional control and should result in the predicted takeoff distances with standard power. Full application of power can be utilized at 84 knots IAS without assistance of nosewheel steering and with full application of rudder. It should be noted that nosewheel steering will allow slightly more rapid application of power during the first portion of the takeoff run. However, it is recommended that nosewheel steering should not be employed excessively because skipping may be encountered which is undesirable from a structural standpoint. After maximum power is attained on the asymmetrical engine, acceleration should be continued to the takeoff speeds shown.

STOPPING DISTANCE.

Flight tested distances to stop using hard wheel-braking are shown in figure A3-25. These data are for operation in the takeoff configuration and can be used to determine accelerate and stop distances by adding accelerate distance, stop distance, and a distance allowance for time required to recognize an abort situation and apply brakes. Experience has shown that a 3-second reaction time satisfactorily accounts for the distance traveled.

Reverse thrust stopping distances are also included. Variables that affect reverse thrust stopping distances from a specific airspeed are altitude, gross weight, number of operative engines/propellers, and rpm. The inclusion of the specific effects of all these parameters would result in a complex chart. Simplification was accomplished by assuming a nominal reduction in stopping distances that are within aircraft capability when using normal pilot technique. These reverse thrust distances assume symmetrical 2-engine reverse thrust at 2500 rpm.

Correction grids for wind, slope, and RCR are also supplied. Entry is made with a stopping distance either with or without reverse thrust. This distance is corrected by following the guide lines for the specific parameters. Use figure A3-22 when runway slope exceeds 2 percent.

AUTOMATIC PROPELLER FEATHERING.

The automatic propeller feathering system is assumed to be operative and armed for all takeoff operations. Critical field length data provided here are applicable with the system operative or inoperative, provided that manual feathering of the proper engine is accomplished in the same time normally required for the automatic feathering system to feather the propeller of the failing engine. If the autofeathering system is inoperative the crew must be alerted to feather the propeller of a failed engine immediately.

SAMPLE PROBLEM.

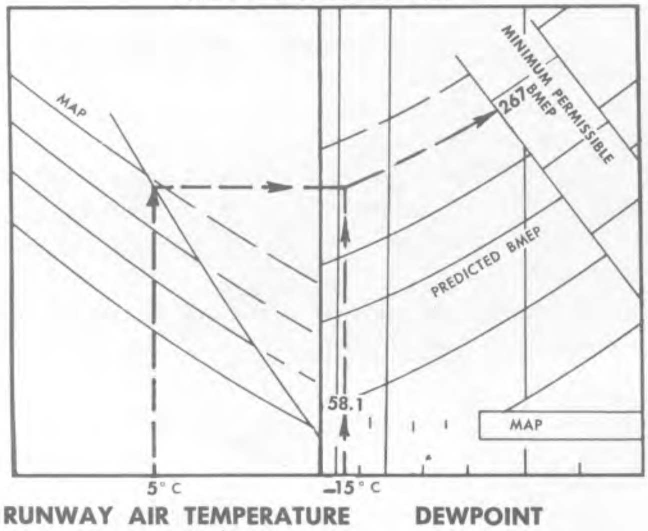
Conditions.

- Pressure altitude—2000 ft
- Runway air temperature—5°C
- Dewpoint— −15°C
- Takeoff gross weight—130,000 lb
- Runway condition reading (RCR)—16
- Runway length available—8000 ft
- Obstacle height—200 ft
- Obstacle distance from end of runway—3000 ft

- Wind—23 knots, steady; gusts to 30 knots
- Angle between runway heading and reported wind direction—30 degrees
- Slope—1-percent uphill
- Density altitude (figure A1-12)—1250 ft

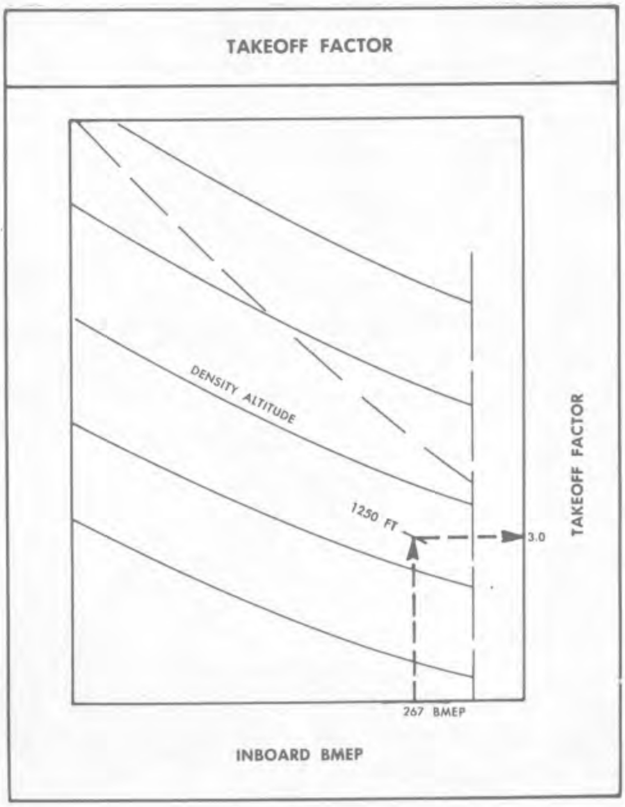
a. **Maximum Power Prediction.** Enter the 2000-ft Maximum Power Prediction chart, figure A3-1, at the dewpoint temperature (−15°C) and note the corresponding limit MAP (58.1 in. Hg). Keep this value in mind, enter the chart at the runway air temperature of 5°C and proceed vertically until intersecting either the limit MAP just determined or the full-throttle line, whichever is reached first. Then proceed horizontally until intersecting the dewpoint line. From this point slide along a constant BMEP line to the minimum permissible BMEP scale and read 267.

MAXIMUM POWER PREDICTION
2000 FT PRESSURE ALTITUDE



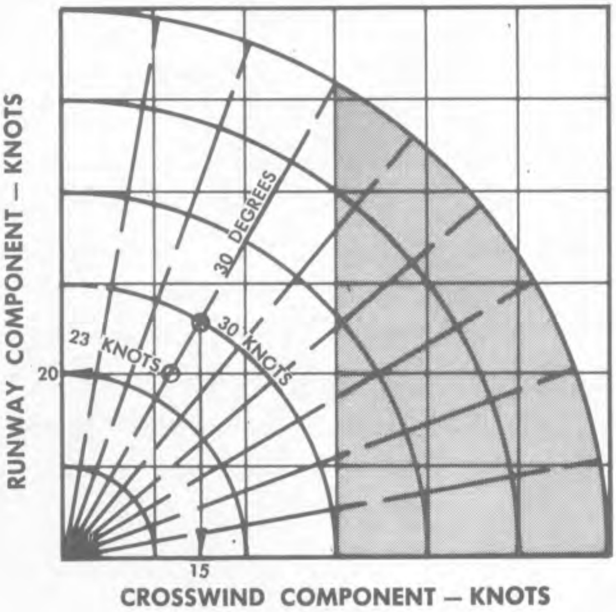
b. **Takeoff Factor.** Enter sheet 1 of figure A3-7 (low blower) with the minimum permissible BMEP (267) and proceed vertically to the density altitude (1250 ft). Move right and read a takeoff factor of 3.0.

c. **Thrust Factor.** Enter the low blower portion of figure A3-8 with the takeoff factor (3.0) and density altitude (1250 ft) and read a thrust factor of 52.6.

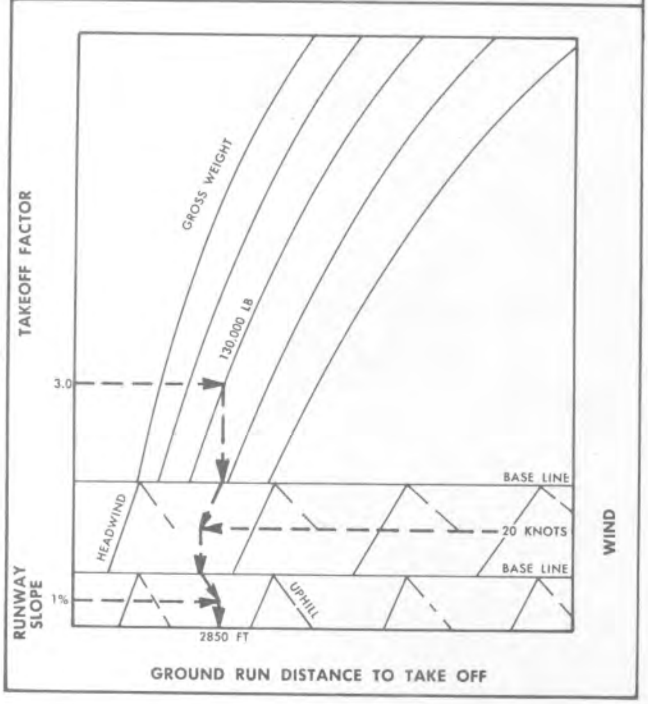


d. **Wind Components.** Enter sheet 2 of figure A3-9 with the steady wind (23 knots) and the angle between the runway and reported wind velocity (30 degrees) and read a headwind component of 20 knots. For the crosswind component, use the steady wind (23) plus the full gust increment (7) and read 15 knots. For this problem we will assume the reported winds are those actually obtained at the runway during the takeoff run.

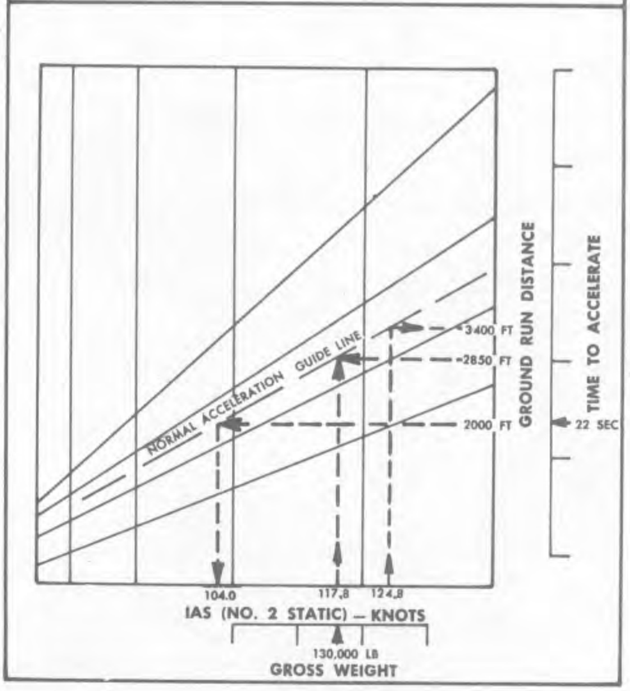
WIND COMPONENT CHART



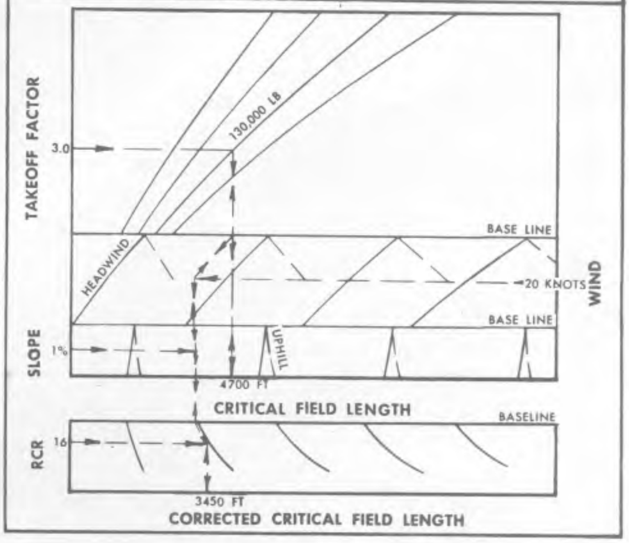
e. **Takeoff Distance.** Enter figure A3-10 with the takeoff factor (3.0) to the takeoff gross weight (130,000 lb) and move down to the base line. Follow the wind and slope guide lines to 20 knots and 1 percent and read a takeoff distance of 2850 feet.


NORMAL TAKEOFF PERFORMANCE — GROUND RUN DISTANCE TO TAKE OFF

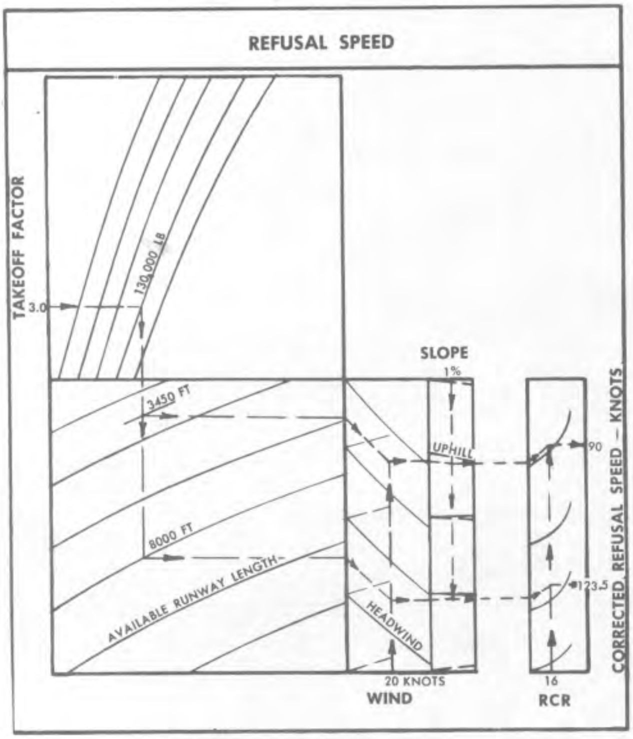
f. **Velocity During Takeoff Ground Run.** Enter figure A3-11 with the takeoff gross weight (130,000 lb) and the takeoff distance corrected for wind and slope (2850 ft). The intersection determines a normal acceleration line. Using an acceleration check distance of 2000 ft, intersect the normal acceleration guide line and read 104 knots IAS on the horizontal scale. Time to accelerate to this distance is 22 seconds. To determine an adjusted takeoff distance for the increase in takeoff speed (7 knots) due to the gust increment, enter with the adjusted takeoff speed (117.8 + 7 or 124.8) to the established normal acceleration guide line and read 3400 feet.


NORMAL TAKEOFF PERFORMANCE — VELOCITY DURING TAKEOFF GROUND RUN

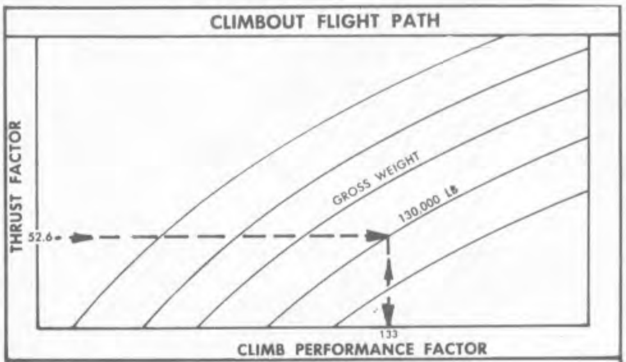
g. **Critical Field Length.** Enter figure A3-12 with the takeoff factor (3.0) and gross weight (130,000 lb). Drop vertically and account for wind (20-knots), slope (1%), and RCR (16), reading a critical field length of 3450 feet. Obtain the critical airspeed for engine failure from figure A3-13. Use figure A3-15 for reverse thrust critical field lengths.

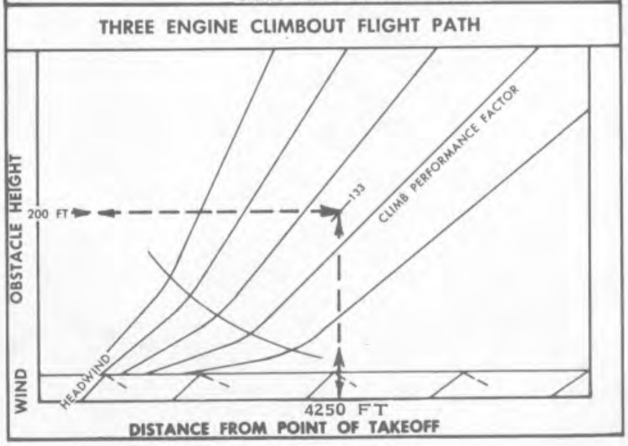

CRITICAL FIELD LENGTH

h. **Refusal Speed and Critical Airspeed for Engine Failure.** Enter sheet 1 of figure A3-13 with the takeoff factor (3.0) and gross weight (130,000 lb) proceed to the available runway length (8,000 ft), correct for wind (20 knots), slope (1%), RCR (16) and read a refusal speed of 123.5 knots IAS. If there were no gusts, refusal speed would be the takeoff speed (117.8 knots). The critical airspeed for engine failure is found in the same manner except that 3450 ft (critical field length) is used for the available runway. This procedure results in a critical speed for engine failure of 90 knots IAS.



i. **Refusal Distance.** Enter figure A3-11 with the refusal speed (123.5 knots) and the normal acceleration line and read a refusal distance of 3300 feet. Distance at the critical airspeed (90 knots) for engine failure is 1350 feet.





j. **Three-Engine Climbout Flight Path.** Enter figure A3-14, sheet 1, at the thrust factor (52.6) and proceed horizontally to the takeoff gross weight (130,000 lb). Drop vertically to the horizontal scale and read a climb performance factor (133). Next, enter sheet 3, figure A3-14 at the given obstacle height (200 ft) and continue horizontally to the climb performance factor (133).

Drop vertically and read a zero wind distance of 4250 feet. Since it is improbable that wind velocities measured at the runway are applicable during climbout, no headwind credit was taken. Total distance to clear the given obstacle is 3450 + 4250 or 7700 feet. Thus, obstacle clearance is assured with no flight path deviation.

MAXIMUM POWER PREDICTION CHART
R3350-93 ENGINE — LOW BLOWER
RETARD SPARK (20°)
2900 RPM — 115/145 GRADE FUEL
SEA LEVEL AND 2000 FT PRESSURE ALTITUDE

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

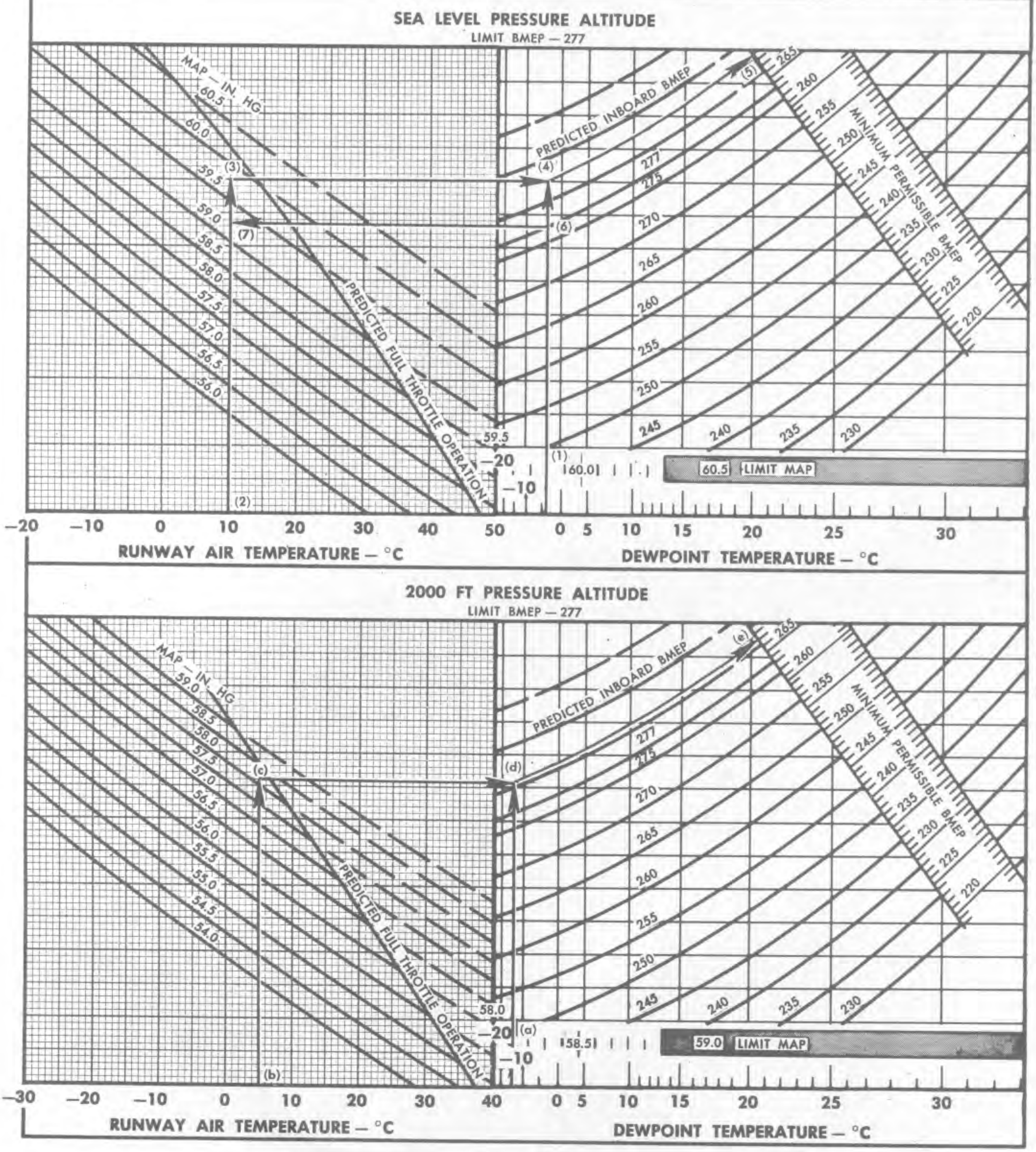


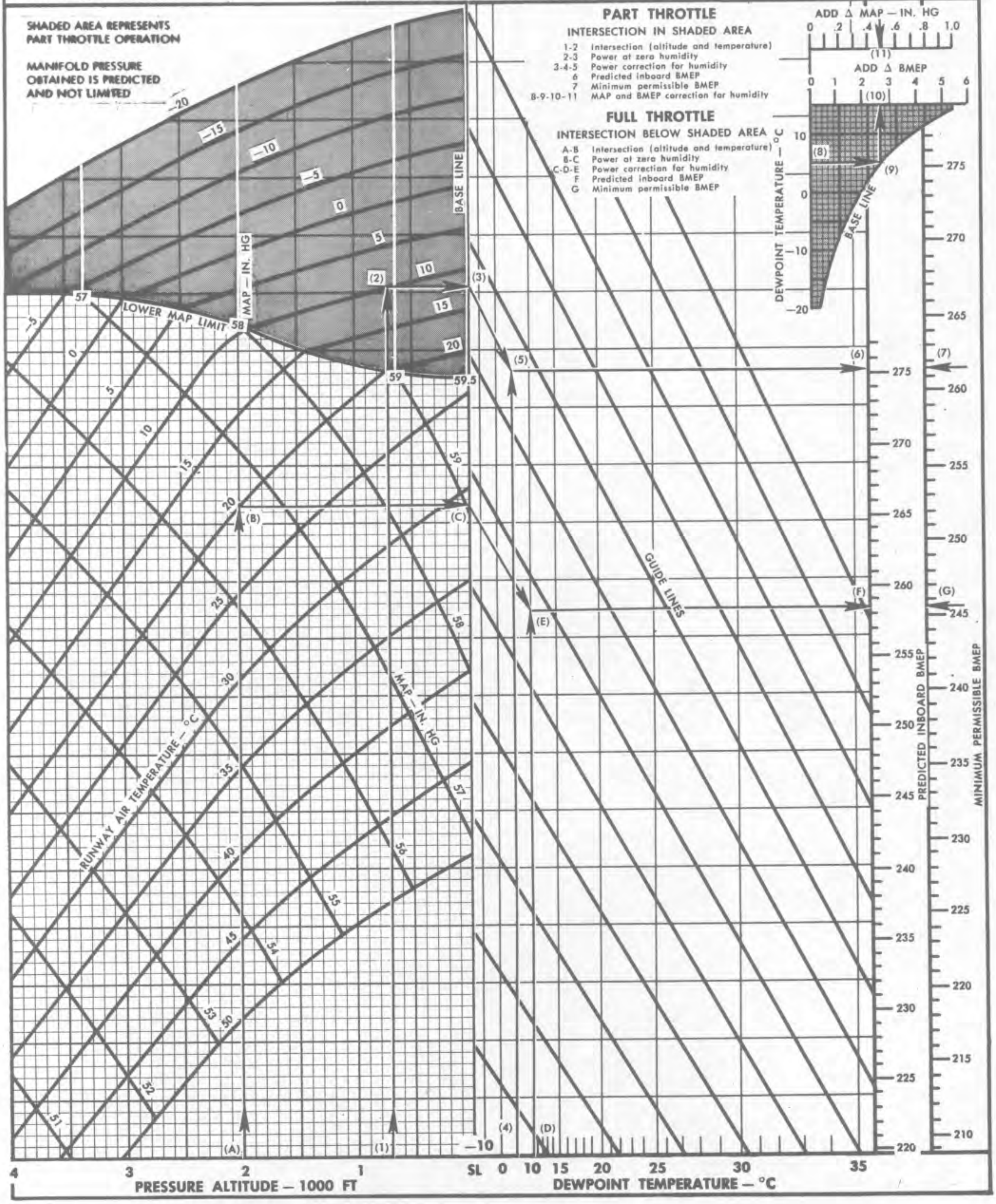
Figure A3-1

R3350-93 ENGINE MAXIMUM POWER PREDICTION CHART — LOW BLOWER

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

RETARD SPARK (20°)
2900 RPM — 115/145 GRADE FUEL
SEA LEVEL TO 4000 FT PRESSURE ALTITUDE

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/69598-O


SHADED AREA REPRESENTS PART THROTTLE OPERATION

MANIFOLD PRESSURE OBTAINED IS PREDICTED AND NOT LIMITED

PART THROTTLE

INTERSECTION IN SHADED AREA

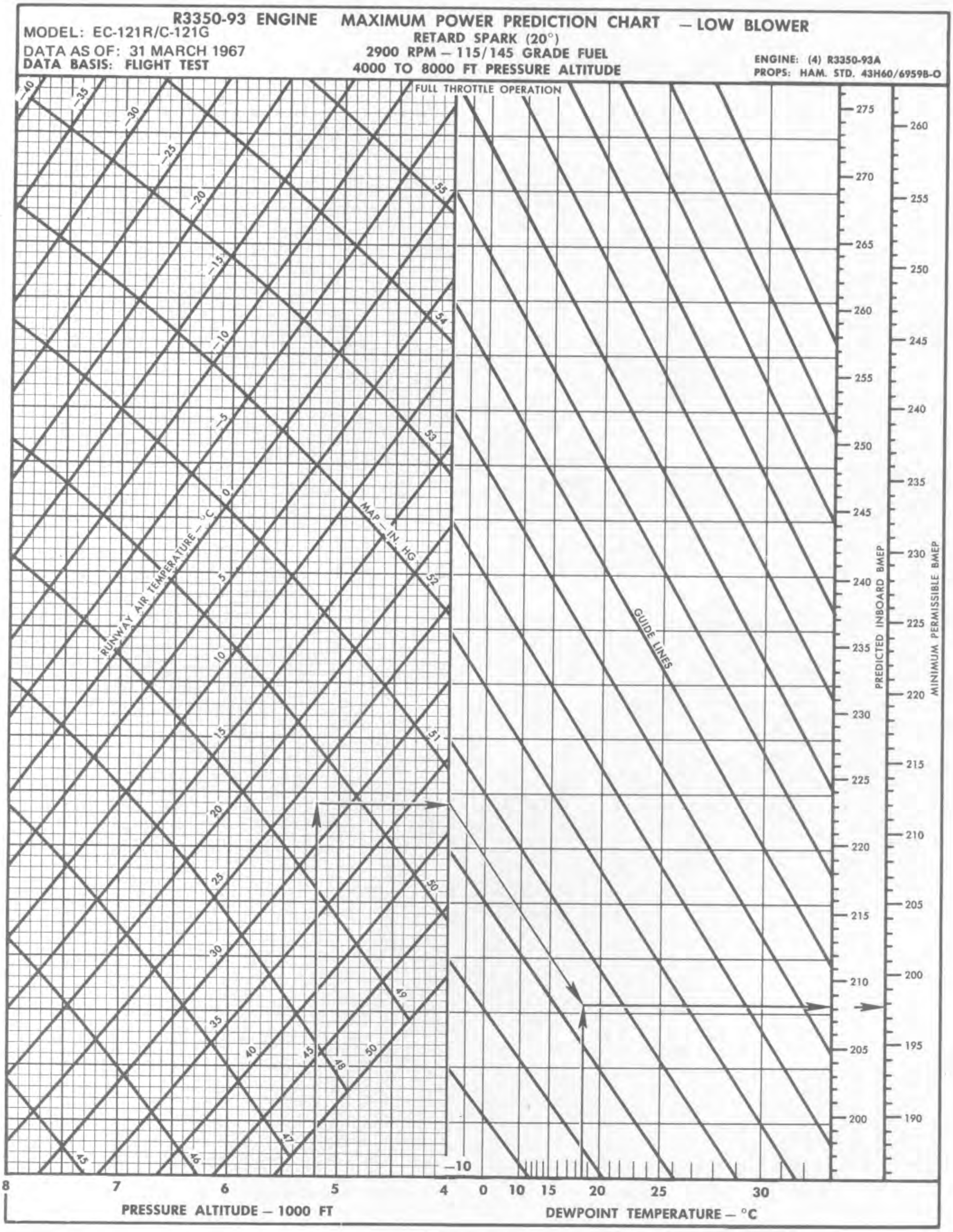
1-2	Intersection (altitude and temperature)
2-3	Power at zero humidity
3-4-5	Power correction for humidity
6	Predicted inboard BMEP
7	Minimum permissible BMEP
8-9-10-11	MAP and BMEP correction for humidity

FULL THROTTLE

INTERSECTION BELOW SHADED AREA

A-B	Intersection (altitude and temperature)
B-C	Power at zero humidity
C-D-E	Power correction for humidity
F	Predicted inboard BMEP
G	Minimum permissible BMEP

Figure A3-2



R3350-93 ENGINE MAXIMUM POWER PREDICTION CHART — LOW BLOWER

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

RETARD SPARK (20°)
2900 RPM — 115/145 GRADE FUEL
4000 TO 8000 FT PRESSURE ALTITUDE

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

Figure A3-3

R3350-93 ENGINE MAXIMUM POWER PREDICTION CHART — LOW BLOWER

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

RETARD SPARK (20°)
2900 RPM — 115/145 GRADE FUEL
8000 TO 12000 FT PRESSURE ALTITUDE

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

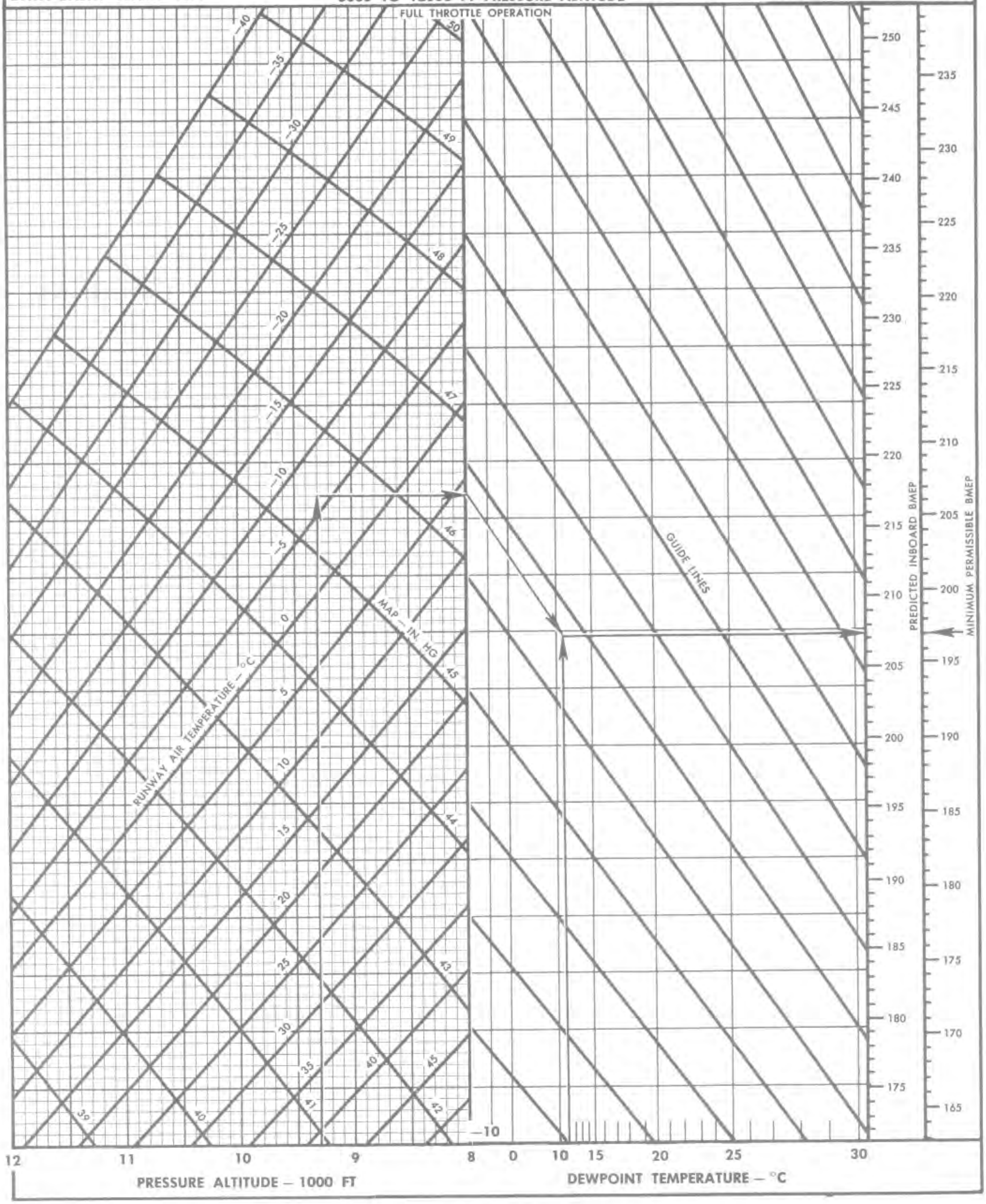


Figure A3-4

MAXIMUM POWER PREDICTION CHART
R3350-93 ENGINE — HIGH BLOWER

RETARD SPARK (20°)
2600 RPM — 115/145 GRADE FUEL
11000 TO 15000 FT PRESSURE ALTITUDE

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

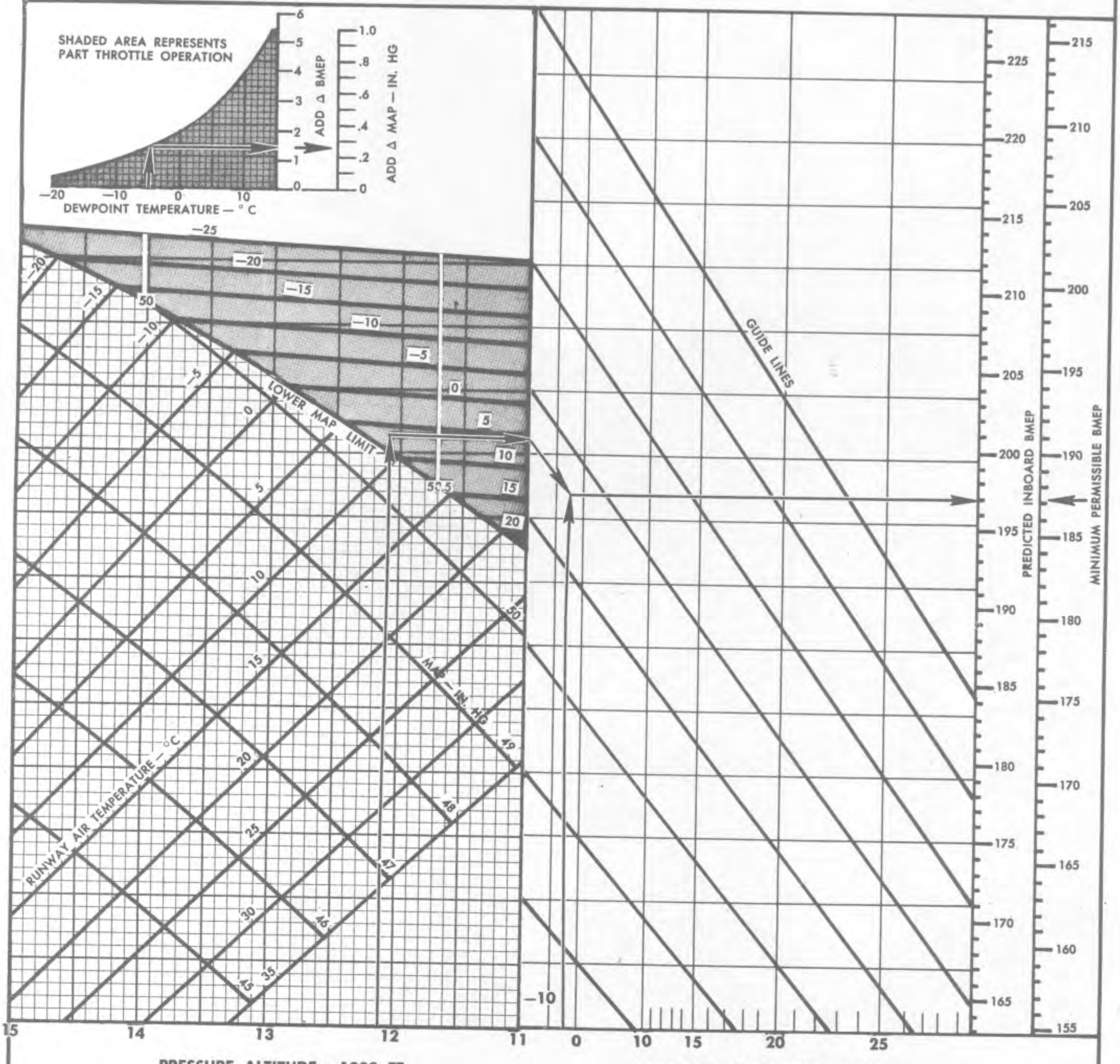


Figure A3-5

MAXIMUM POWER PREDICTION CHART—R3350-93 ENGINE
100/130 GRADE FUEL—2900 RPM

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: CALCULATED

ENGINE: (4) R3350-93
PROPS: HAM. STD. 43H60/6959B-O

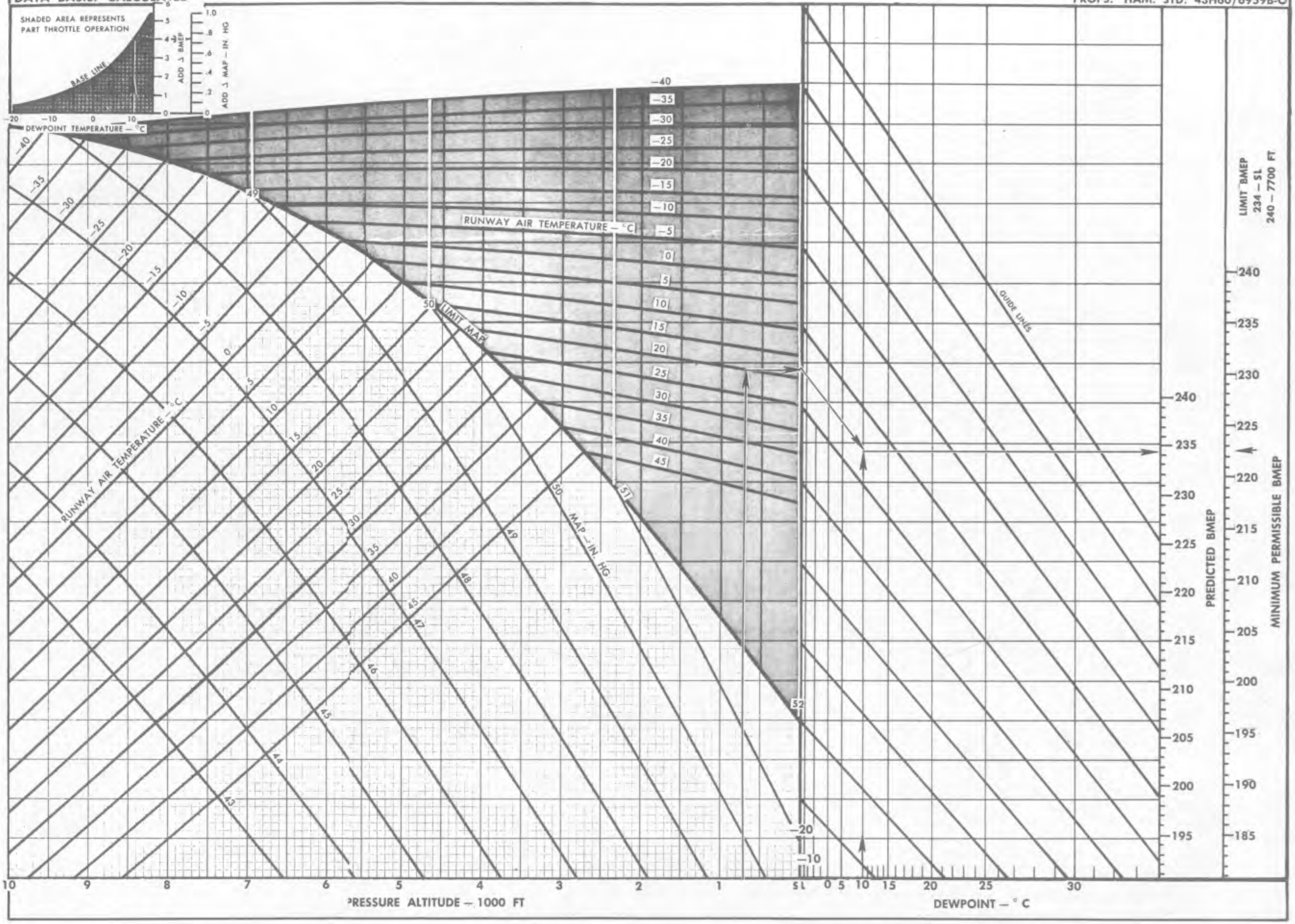
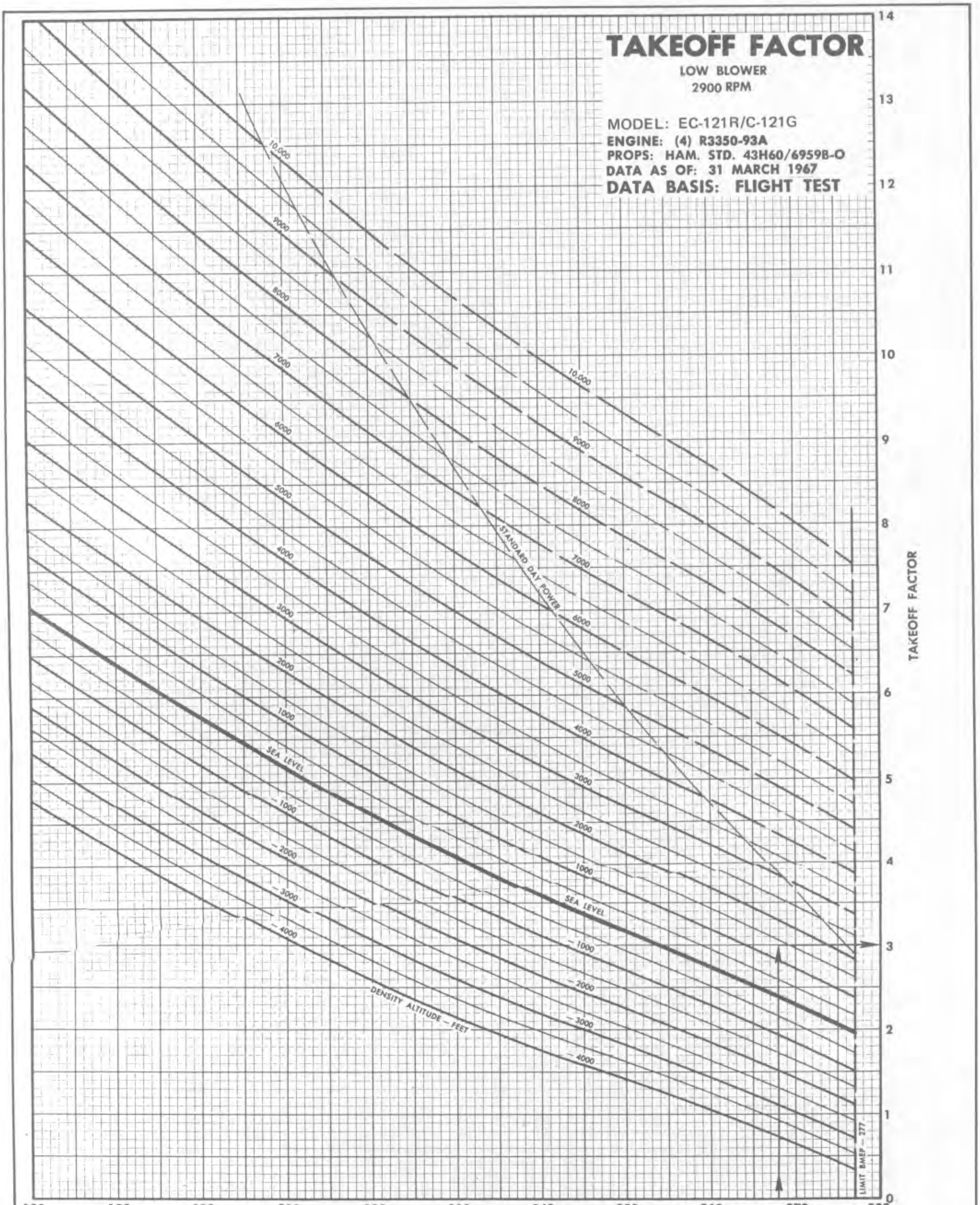


Figure A3-6



TAKEOFF FACTOR

LOW BLOWER
2900 RPM

MODEL: EC-121R/C-121G
ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

Figure A3-7 (Sheet 1 of 2)

TAKEOFF FACTOR

2600 RPM — HIGH BLOWER

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

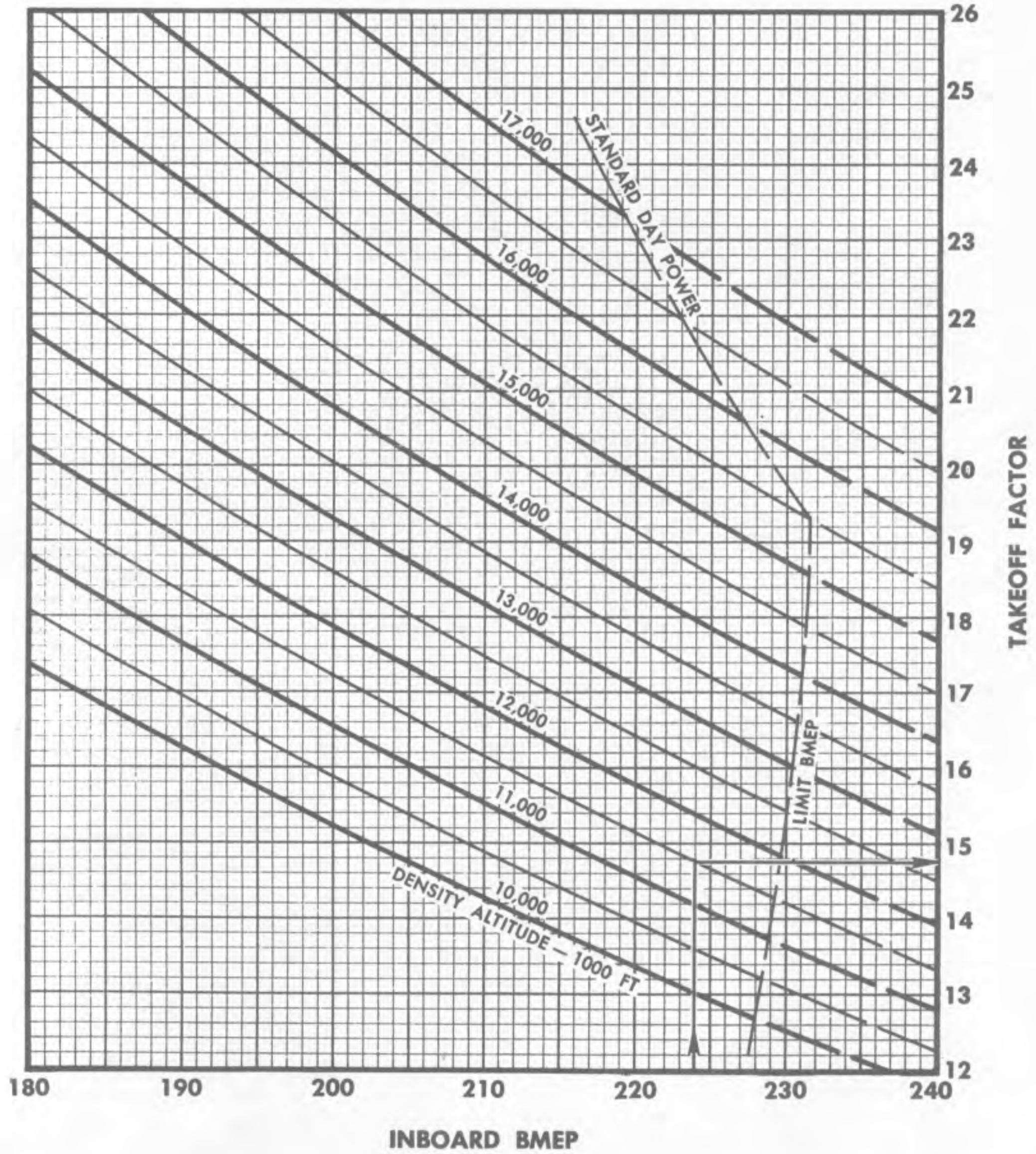


Figure A3-7 (Sheet 2 of 2)

THRUST FACTOR

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

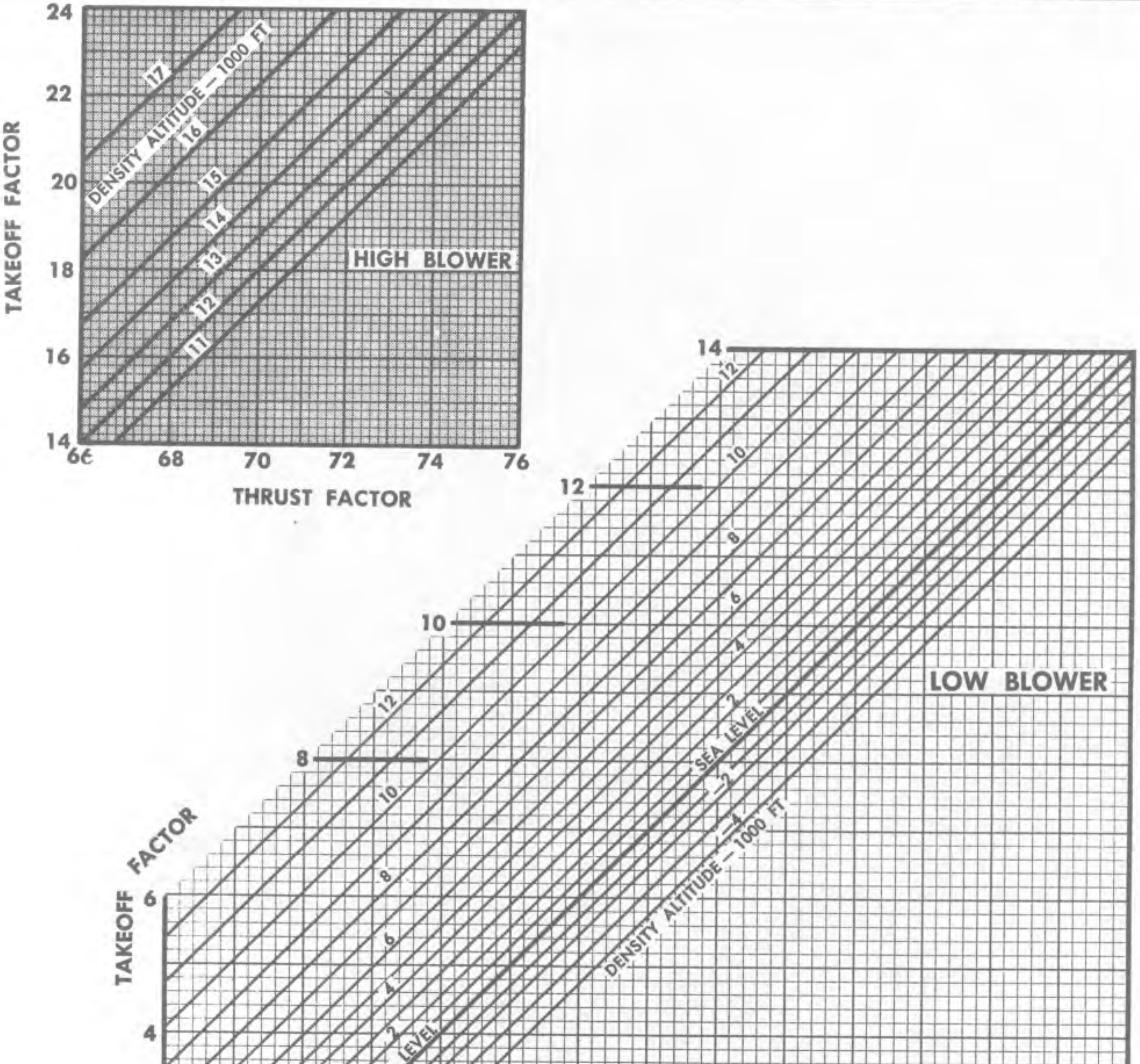


Figure A3-8

WIND SUMMARY TABLE

TYPE OF WIND	HOW TO OBTAIN WIND COMPONENT	USE OF WIND COMPONENT
HEADWIND	Runway Component Enter wind component chart with steady wind value.	Always apply 100% of component to acceleration check. Apply 50% of component to takeoff and landing distances.* Do not apply headwinds for terrain clearance.
TAILWIND	Runway Component Enter wind component chart with steady wind value plus the gust increment	Always apply 100% of component to acceleration check. Apply 150% of component to all takeoff and landing distances. Apply 150% of component for terrain clearance.
CROSSWIND	Crosswind Component Enter wind component chart with steady wind value plus the gust increment	Always adjust ground minimum control speed for 100% of component. Check necessity of increased takeoff and landing speeds.
GUSTS	Gust Increment Reported wind in excess of steady wind value	Always increase takeoff speed, threshold speed, and landing speed by the full gust increment not to exceed 10 knots. ACCELERATION CHECKS NOT VALID DURING GUST CONDITIONS.

* Use 100% of reported winds if they are known to actually exist.

Figure A3-9 (Sheet 1 of 2)

WIND COMPONENT CHART

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL

HEADWINDS

1. 0 - 90 DEGREES
2. ENTER WITH STEADY WIND FOR HEADWIND COMPONENT (1,2)
3. ENTER WITH STEADY WIND PLUS GUST INCREMENT FOR CROSSWIND COMPONENT (1H, 2H)

TAILWINDS

1. 90 - 180 DEGREES
2. ENTER WITH STEADY WIND PLUS GUST INCREMENT FOR TAILWIND AND CROSSWIND COMPONENT (3, 4, 4T)

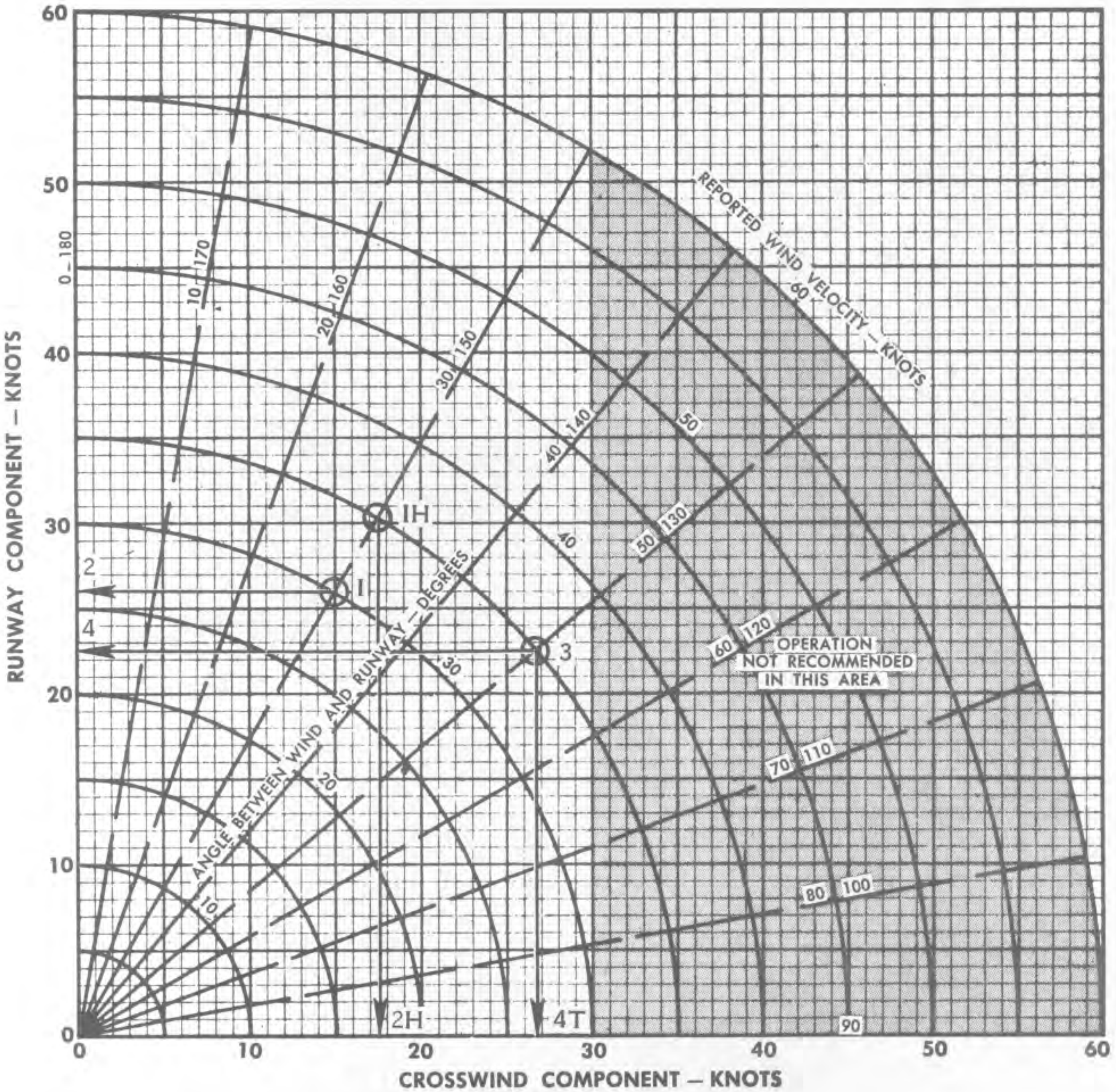


Figure A3-9 (Sheet 2 of 2)

FOUR ENGINE OPERATION

NORMAL TAKEOFF PERFORMANCE – GROUND RUN DISTANCE TO TAKE OFF

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

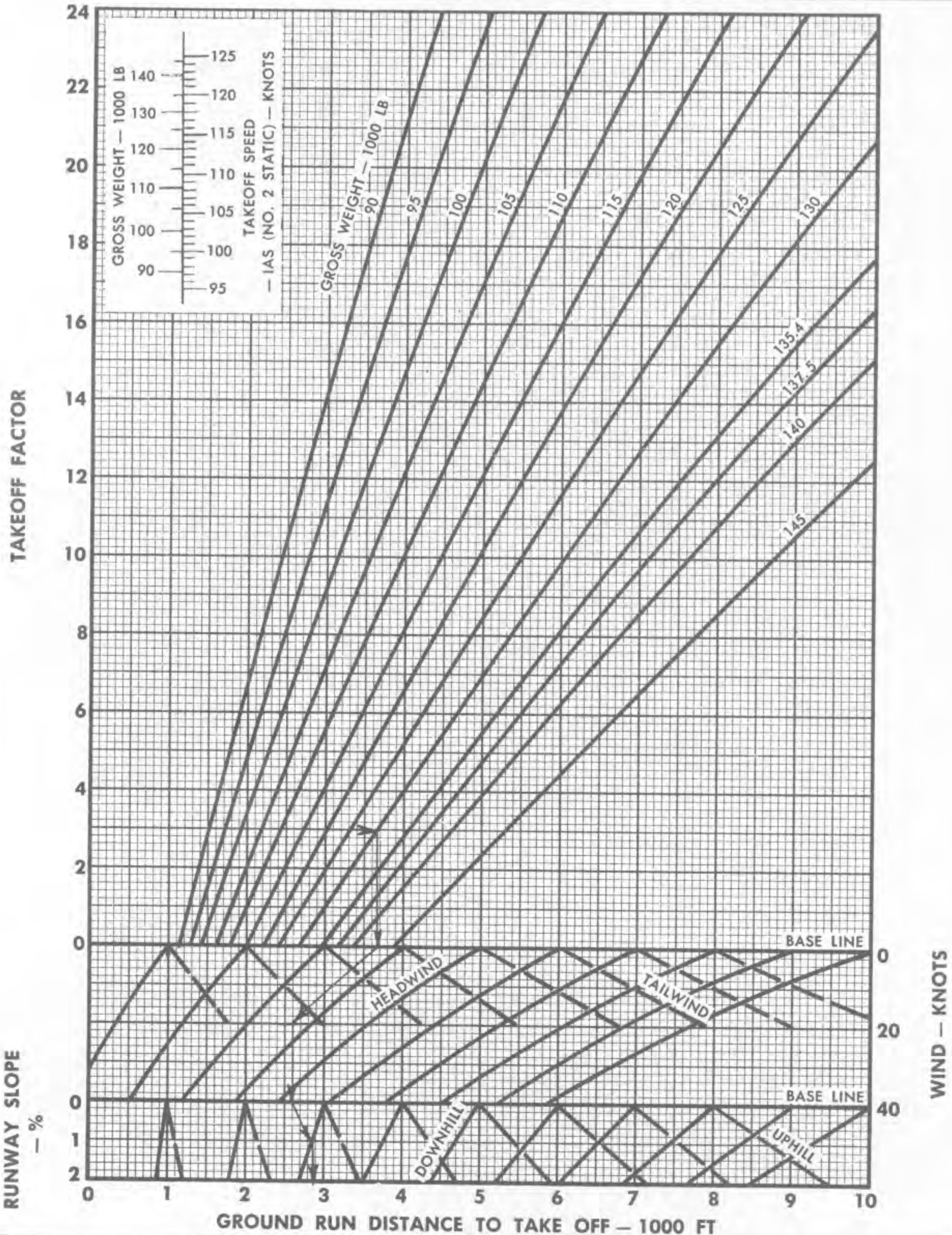


Figure A3-10

FOUR ENGINE OPERATION

NORMAL TAKEOFF PERFORMANCE — VELOCITY DURING TAKEOFF GROUND RUN

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL

CONDITION:

1. The normal acceleration guide line for a gross weight is determined with distance entry that has fully accounted for wind and slope effects.

NOTE: IF RSC IS USED, THIS CHART IS NOT VALID.

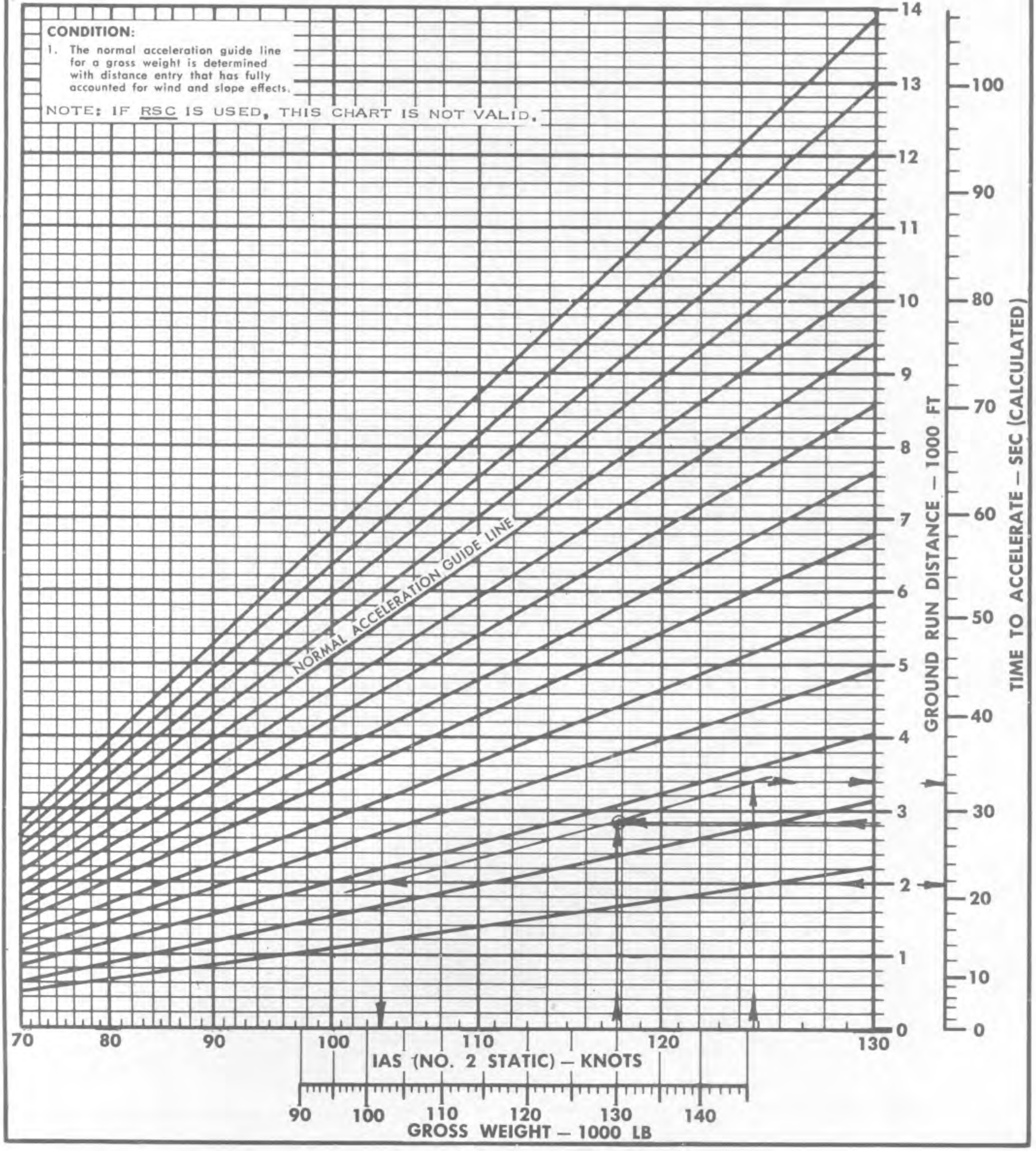


Figure A3-11

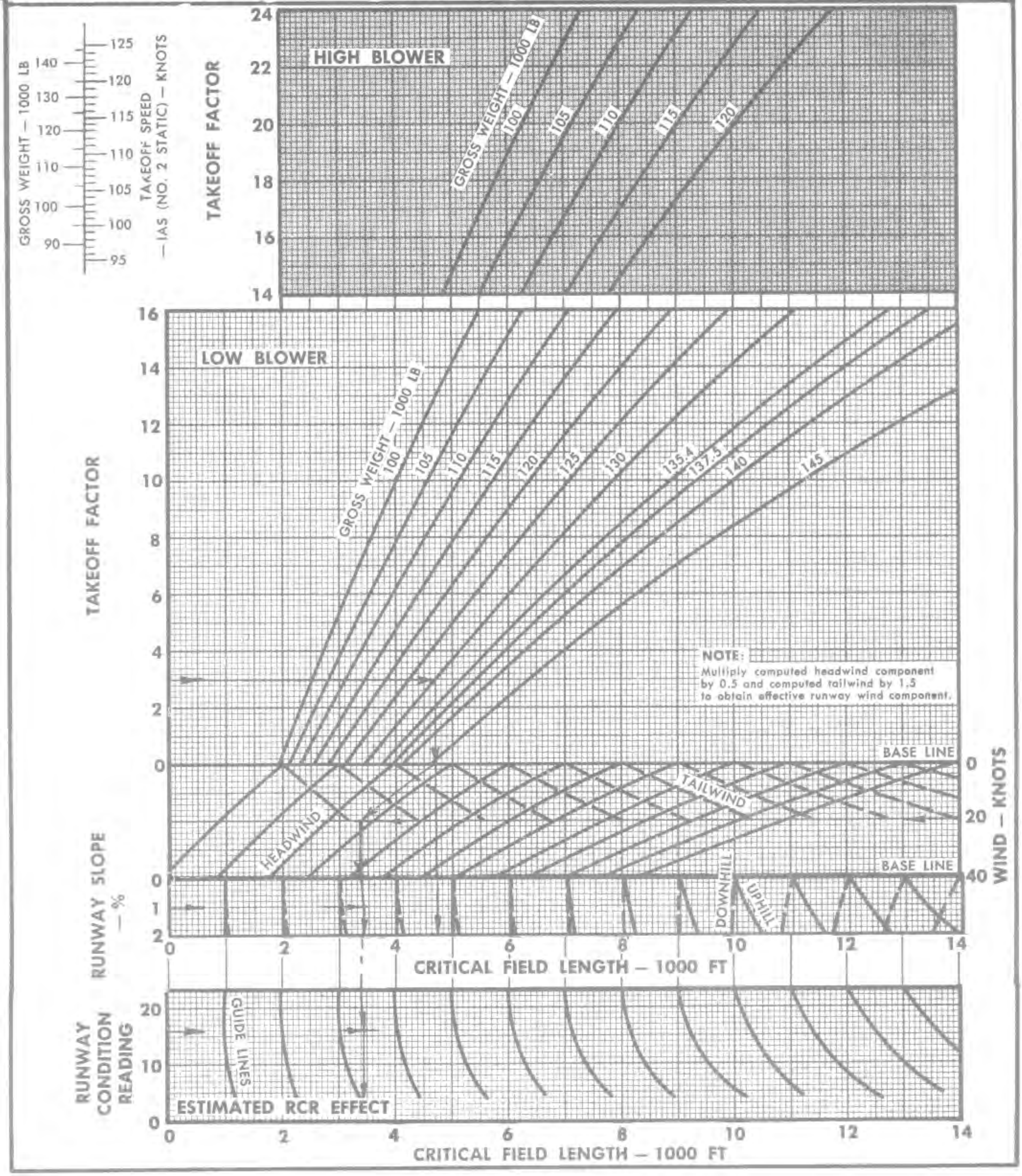
CRITICAL FIELD LENGTH

ZERO OBSTACLE CLEARANCE

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



NOTE:
Multiply computed headwind component by 0.5 and computed tailwind by 1.5 to obtain effective runway wind component.

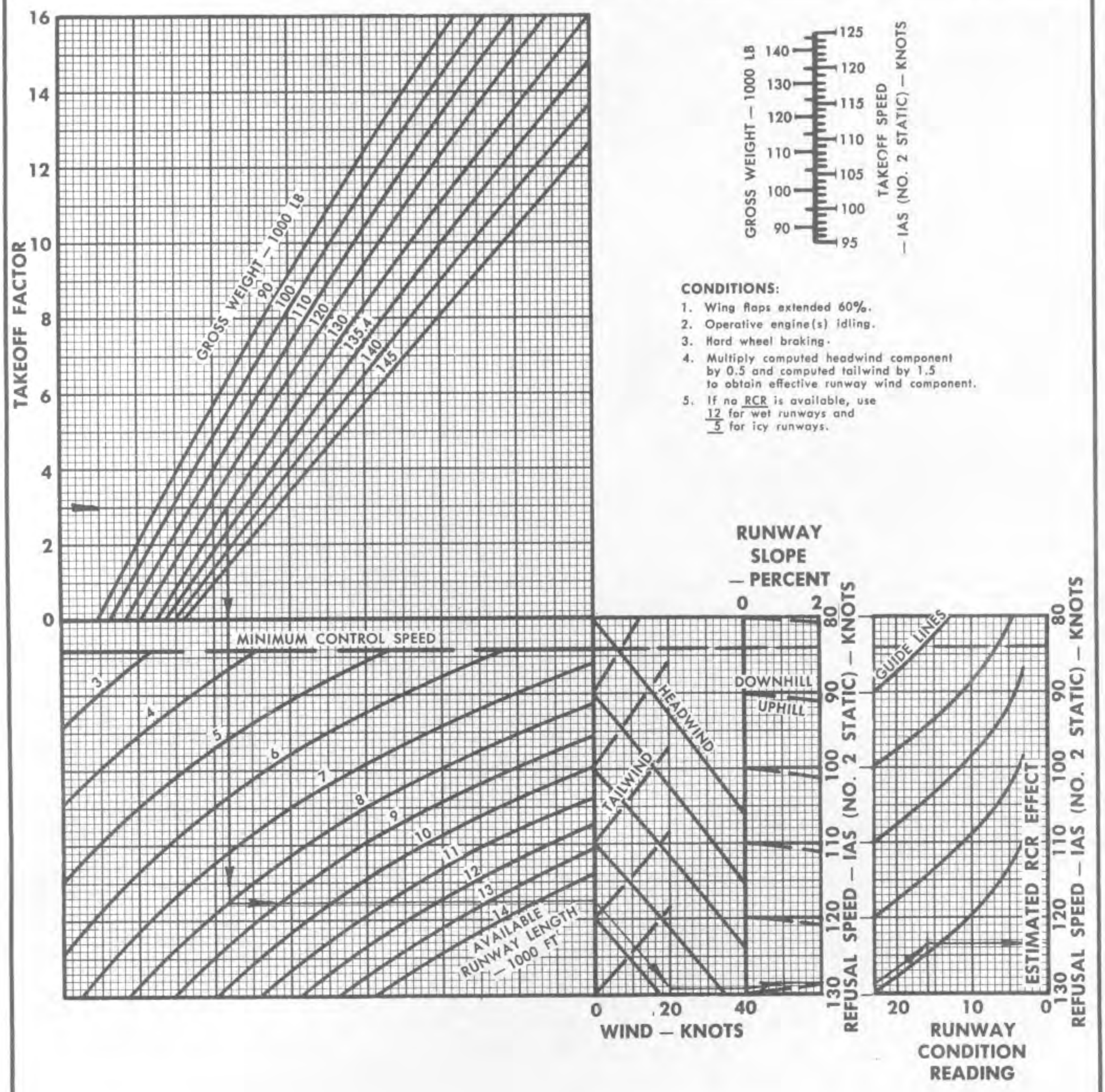
Figure A3-12 (Sheet 1 of 2)

TAKEOFF PERFORMANCE
REFUSAL SPEED
LOW BLOWER

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



CONDITIONS:

1. Wing flaps extended 60%.
2. Operative engine(s) idling.
3. Hard wheel braking.
4. Multiply computed headwind component by 0.5 and computed tailwind by 1.5 to obtain effective runway wind component.
5. If no RCR is available, use 12 for wet runways and 5 for icy runways.

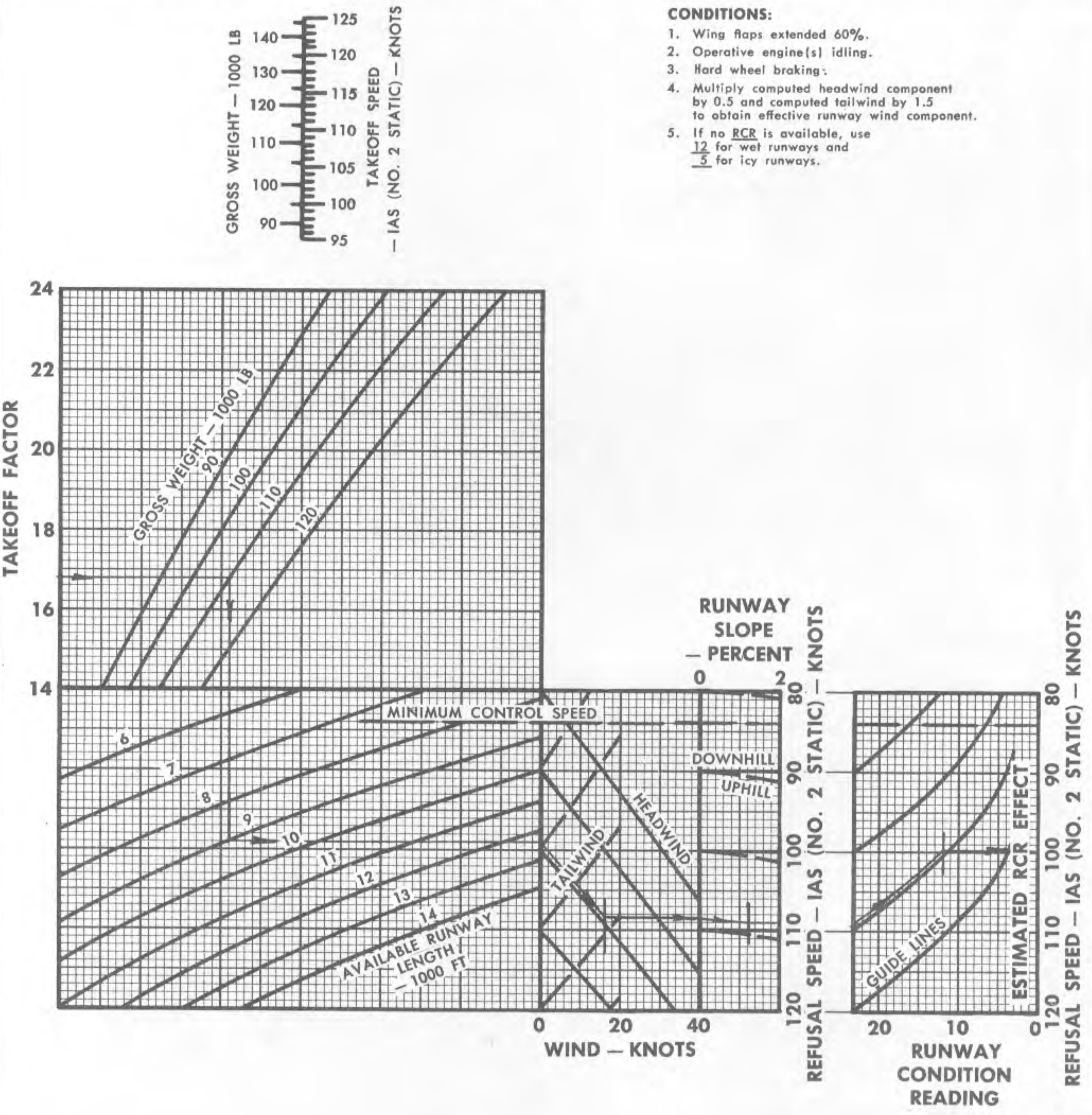
Figure A3-12 (Sheet 2 of 2)

TAKEOFF PERFORMANCE
REFUSAL SPEED
HIGH BLOWER

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



CONDITIONS:

1. Wing flaps extended 60%.
2. Operative engine(s) idling.
3. Hard wheel braking.
4. Multiply computed headwind component by 0.5 and computed tailwind by 1.5 to obtain effective runway wind component.
5. If no RCR is available, use 12 for wet runways and 5 for icy runways.

Figure A3-13 (Sheet 1 of 3)

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

CLIMBOUT FLIGHT PATH

MAXIMUM POWER

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

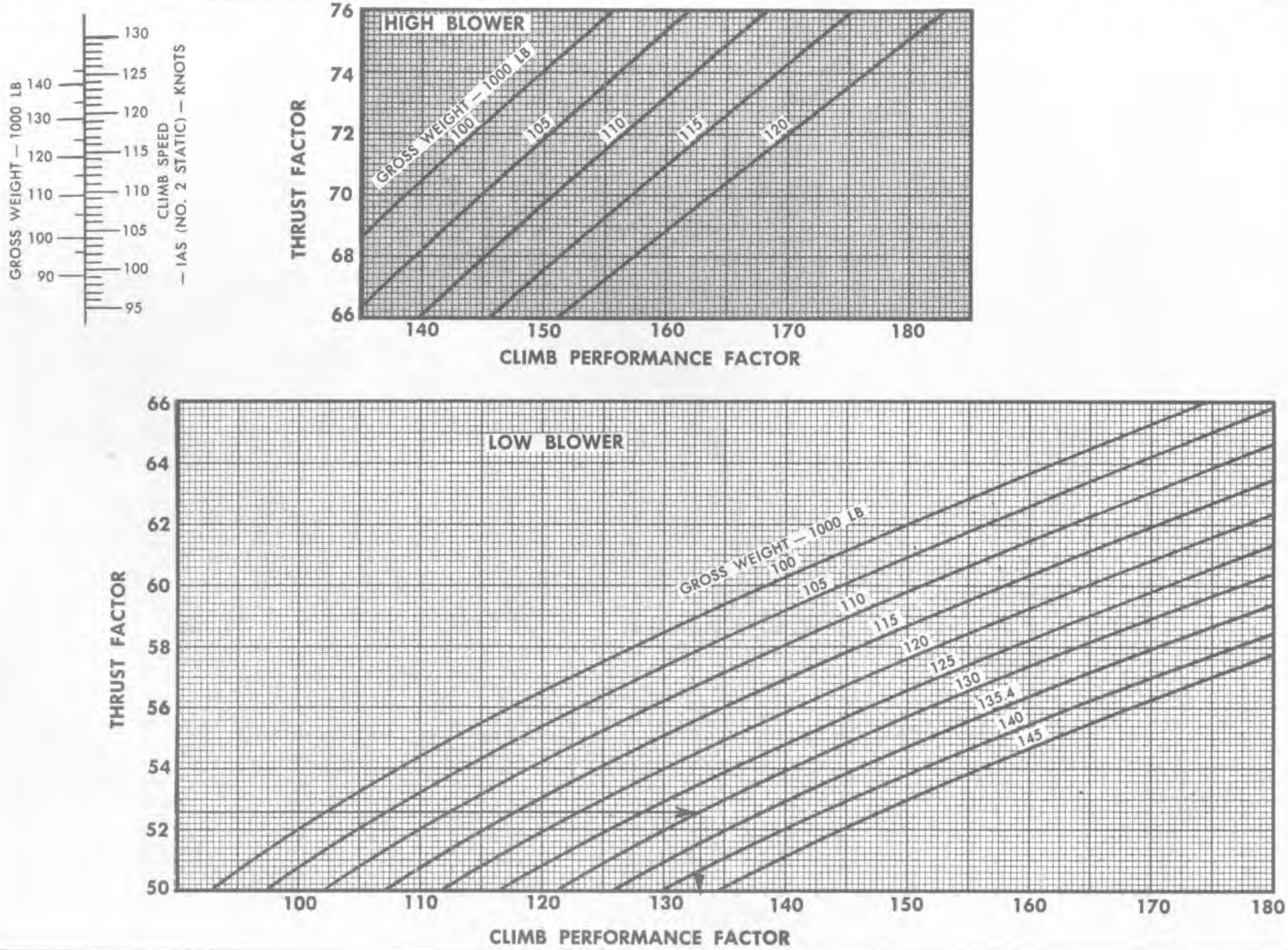


Figure A3-13 (Sheet 2 of 3)

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

FOUR ENGINE OPERATION
NORMAL TAKEOFF PERFORMANCE — FOUR ENGINE
CLIMBOUT FLIGHT PATH
MAXIMUM POWER

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

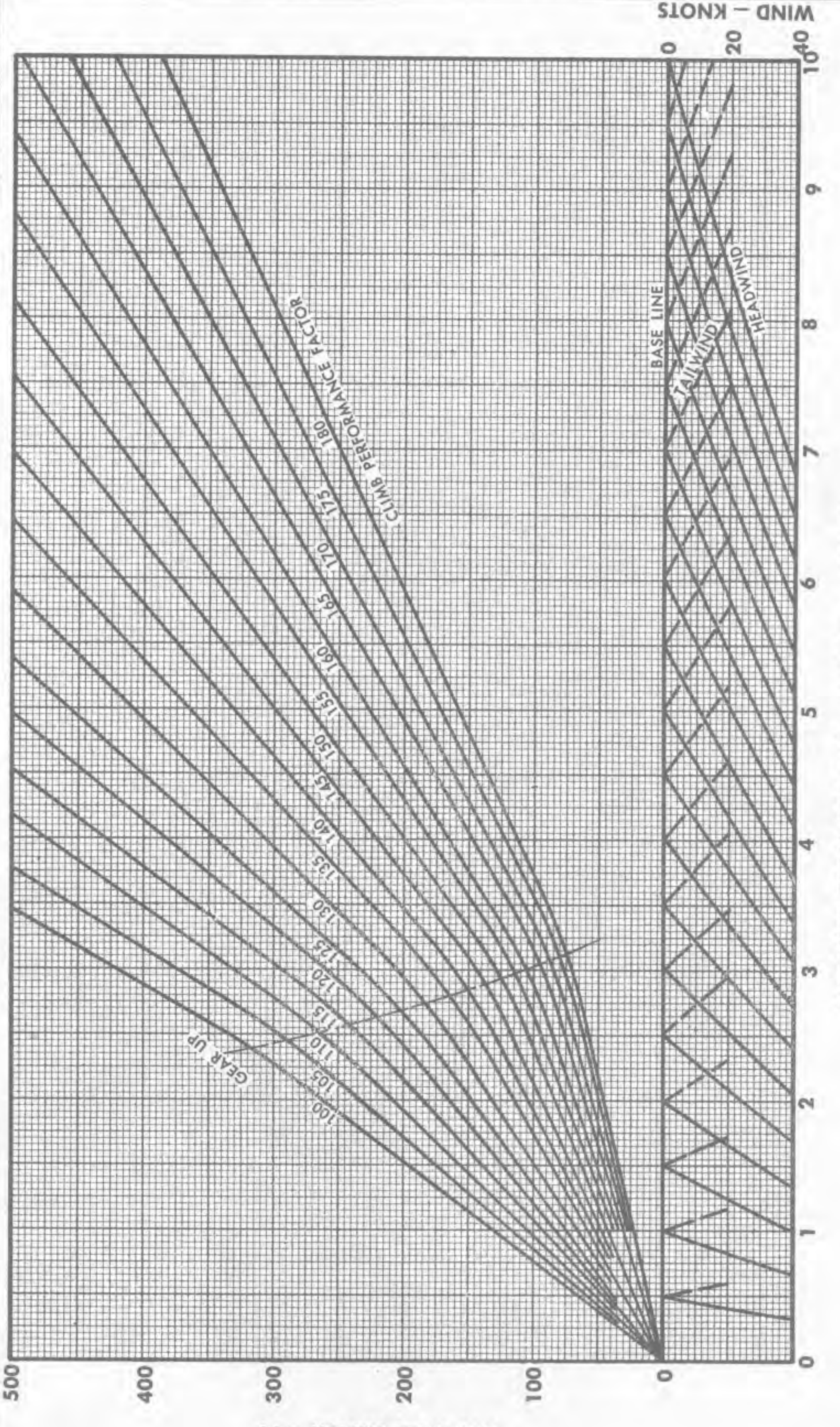


Figure A3-13 (Sheet 3 of 3)

THREE ENGINE OPERATION

THREE ENGINE CLIMBOUT FLIGHT PATH

MAXIMUM POWER

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TESTS

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

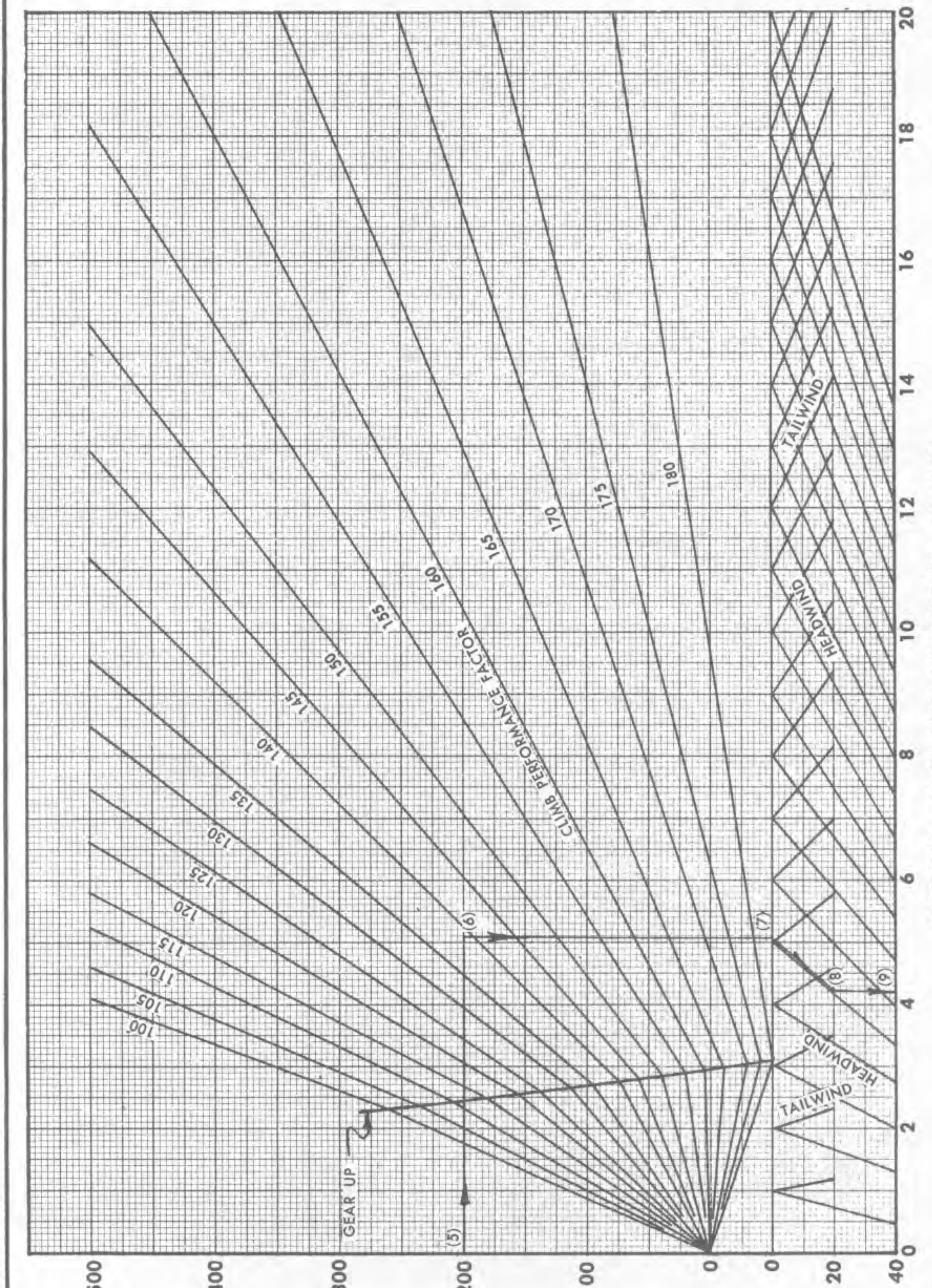


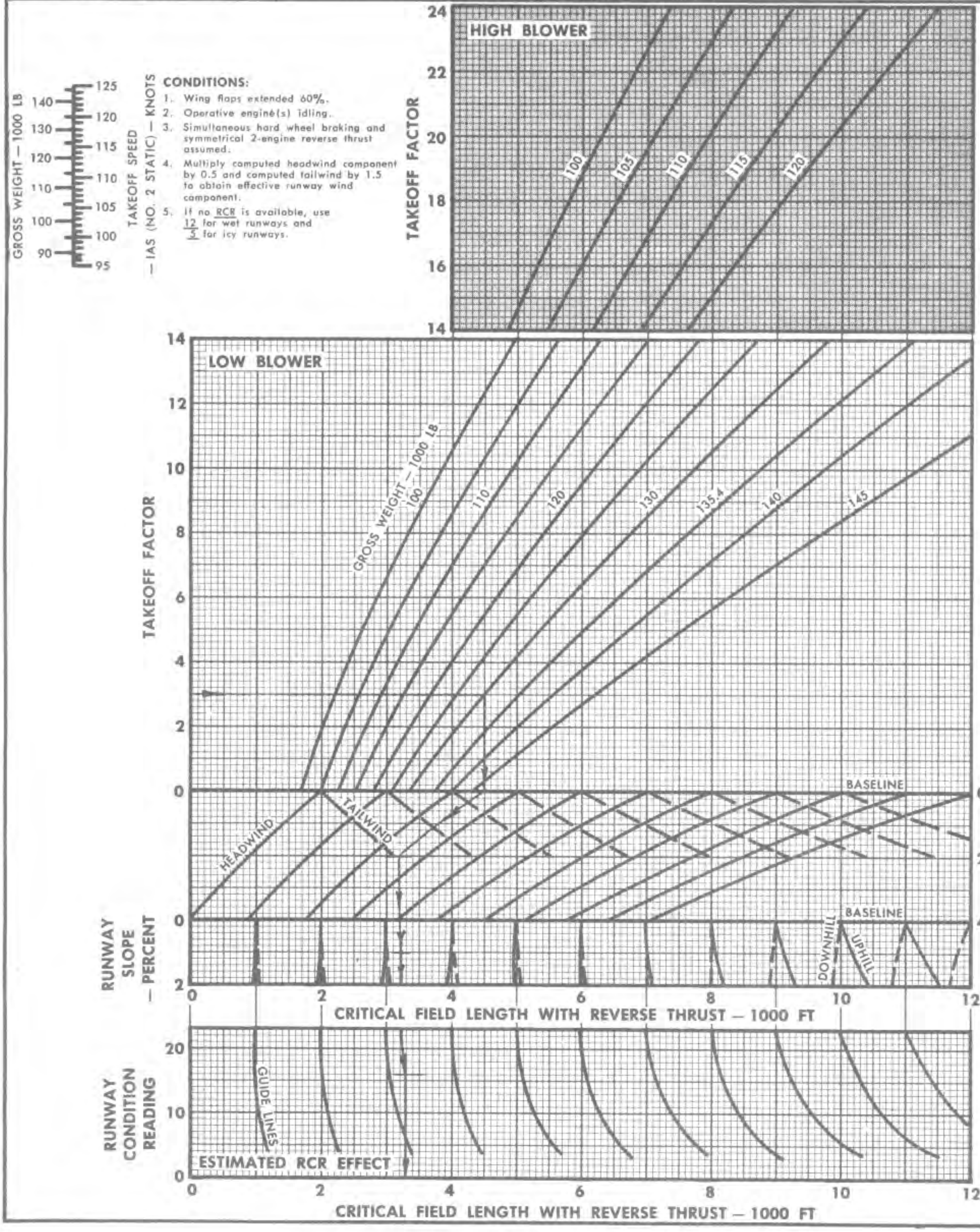
Figure A3-14

CRITICAL FIELD LENGTH
ZERO OBSTACLE CLEARANCE
2 — ENGINE REVERSE THRUST

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: CALCULATED

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL


CONDITIONS:

1. Wing flaps extended 60%.
2. Operative engine(s) idling.
3. Simultaneous hard wheel braking and symmetrical 2-engine reverse thrust assumed.
4. Multiply computed headwind component by 0.5 and computed tailwind by 1.5 to obtain effective runway wind component.
5. If no RCR is available, use 12 for wet runways and 5 for icy runways.

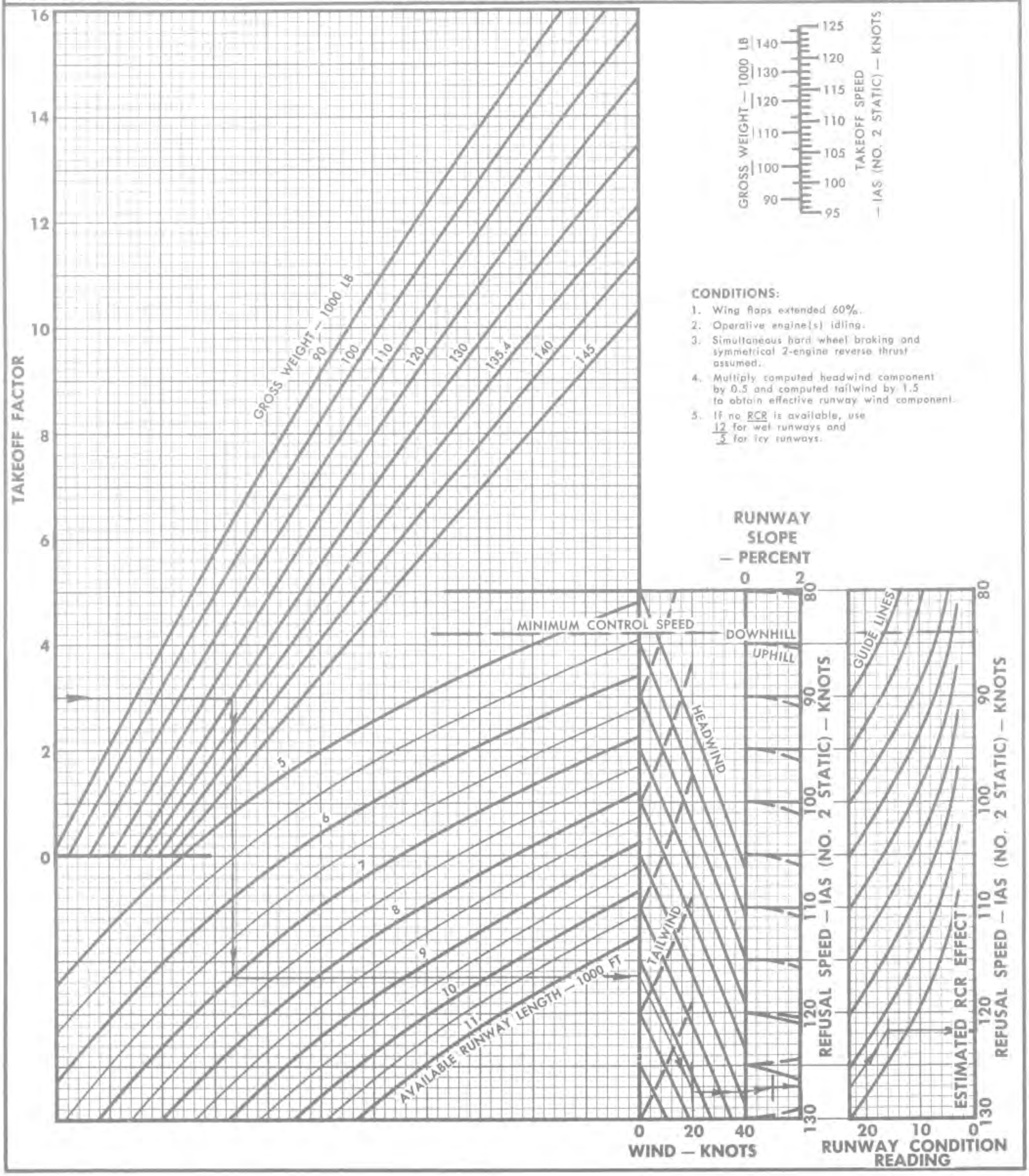
Figure A3-15 (Sheet 1 of 3)

TAKEOFF PERFORMANCE
REVERSE THRUST REFUSAL SPEED
LOW BLOWER

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: CALCULATED

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



CONDITIONS:

1. Wing flaps extended 60%.
2. Operative engine(s) idling.
3. Simultaneous hard wheel braking and symmetrical 2-engine reverse thrust assumed.
4. Multiply computed headwind component by 0.5 and computed tailwind by 1.5 to obtain effective runway wind component.
5. If no RCR is available, use 12 for wet runways and 5 for icy runways.

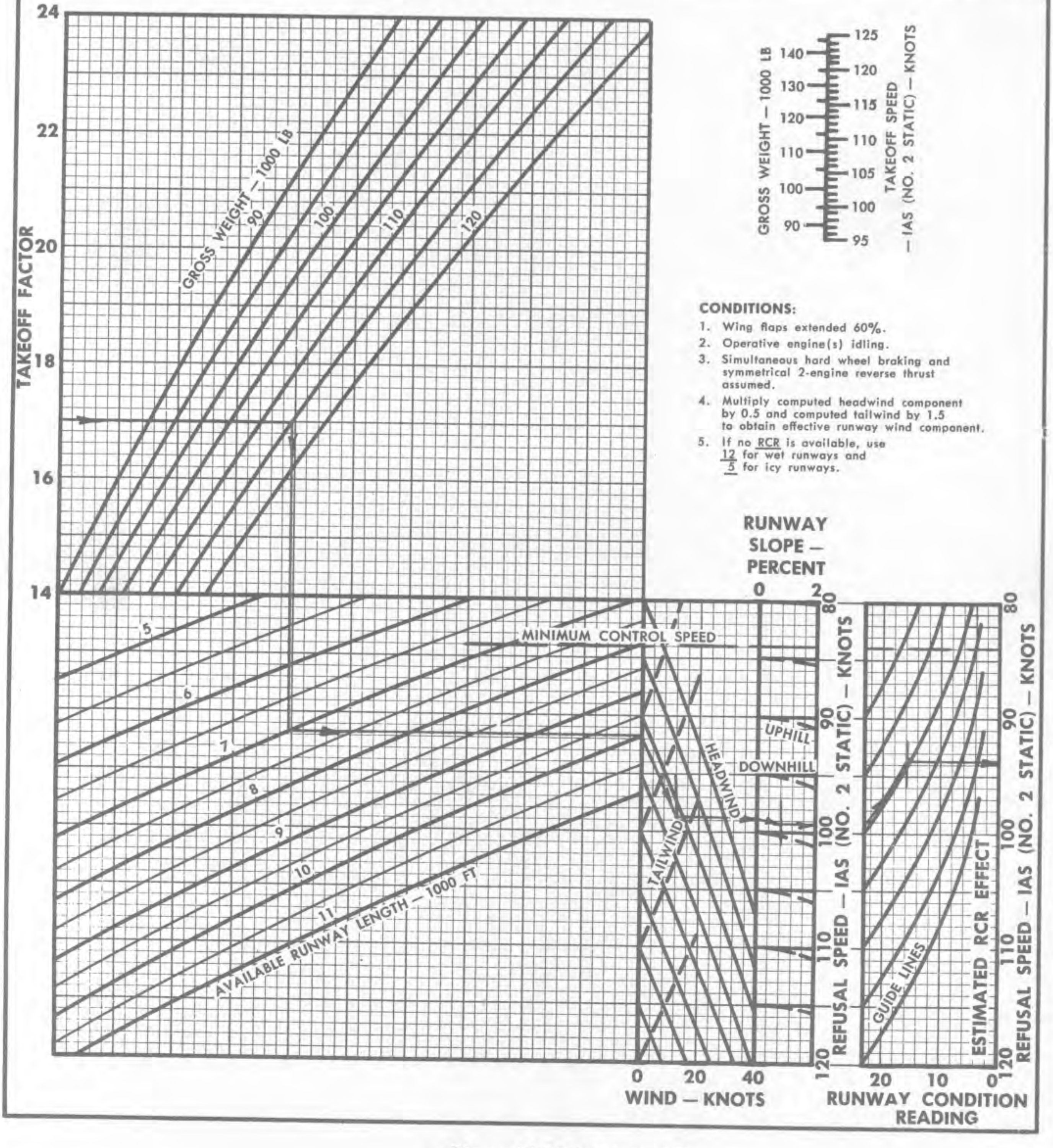
Figure A3-15 (Sheet 2 of 3)

TAKEOFF PERFORMANCE
REVERSE THRUST REFUSAL SPEED
HIGH BLOWER

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: CALCULATED

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



CONDITIONS:

1. Wing flaps extended 60%.
2. Operative engine(s) idling.
3. Simultaneous hard wheel braking and symmetrical 2-engine reverse thrust assumed.
4. Multiply computed headwind component by 0.5 and computed tailwind by 1.5 to obtain effective runway wind component.
5. If no RCR is available, use 12 for wet runways and 5 for icy runways.

Figure A3-15 (Sheet 3 of 3)

THREE ENGINE OPERATION

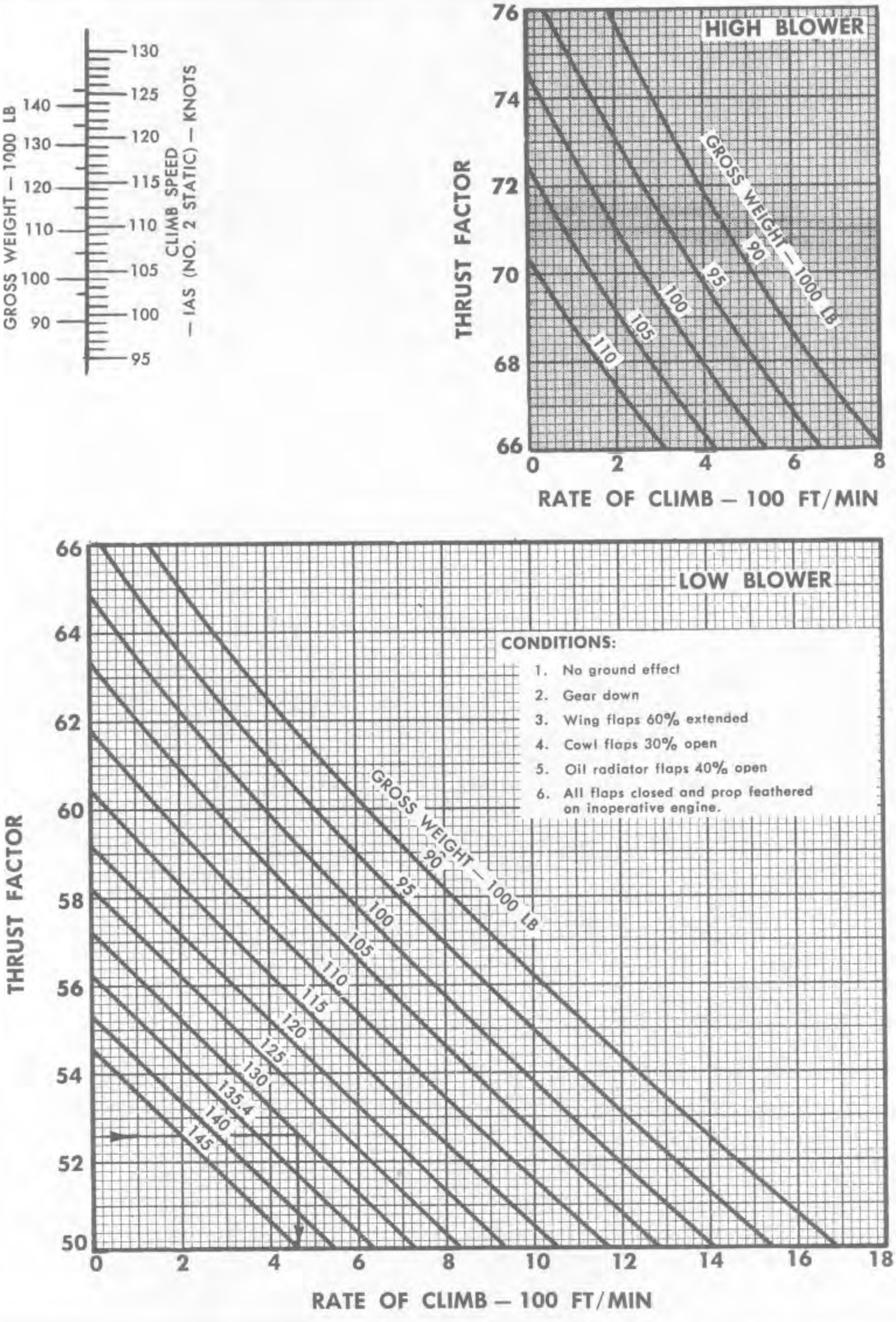
TAKEOFF RATE OF CLIMB

MAXIMUM POWER
GEAR DOWN

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



CONDITIONS:

1. No ground effect
2. Gear down
3. Wing flaps 60% extended
4. Cowl flaps 30% open
5. Oil radiator flaps 40% open
6. All flaps closed and prop feathered on inoperative engine.

Figure A3-16

THREE ENGINE OPERATION

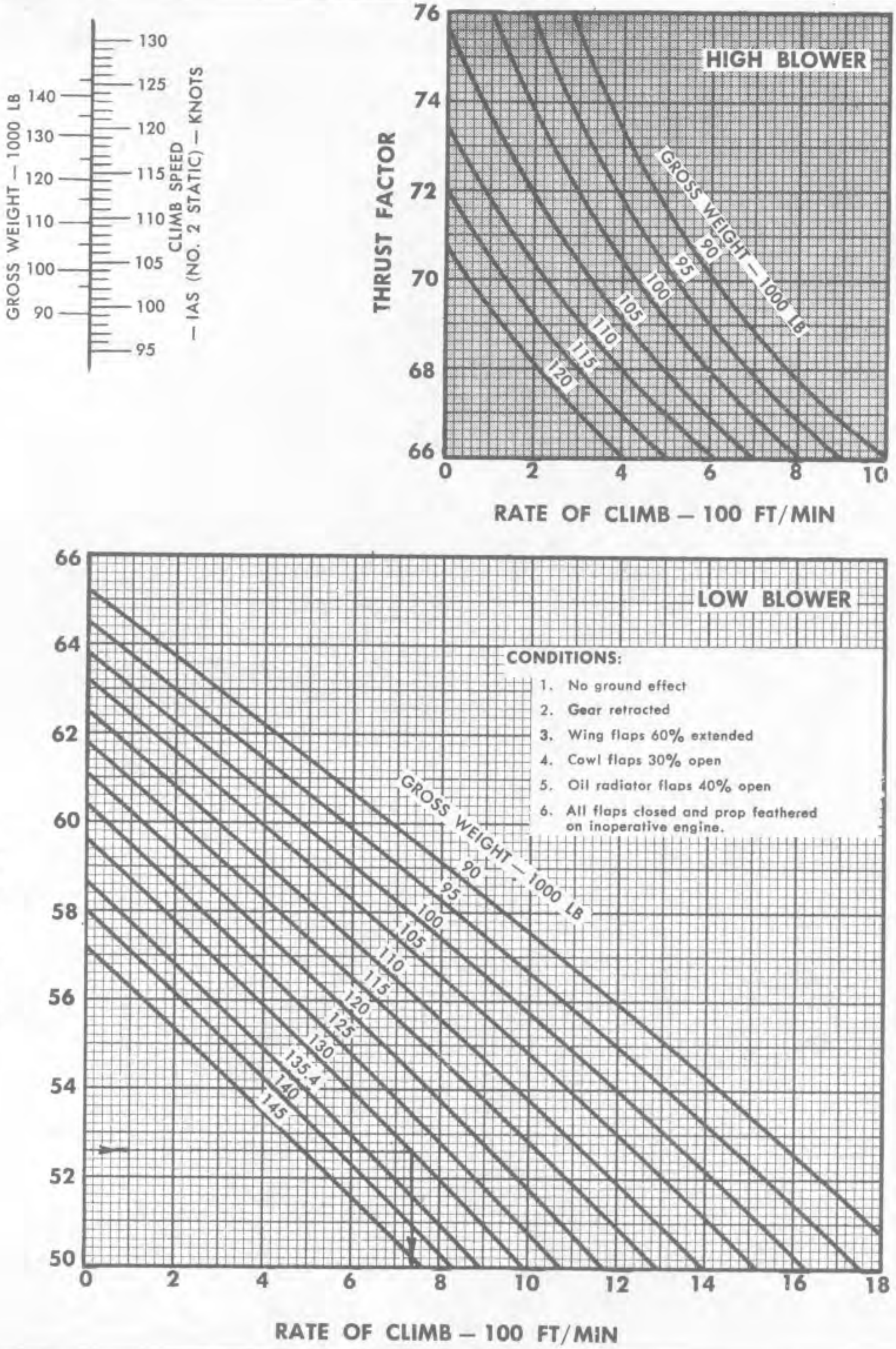
TAKEOFF RATE OF CLIMB

MAXIMUM POWER
GEAR UP

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



CONDITIONS:

1. No ground effect
2. Gear retracted
3. Wing flaps 60% extended
4. Cowl flaps 30% open
5. Oil radiator flaps 40% open
6. All flaps closed and prop feathered on inoperative engine.

Figure A3-17

THREE ENGINE OPERATION

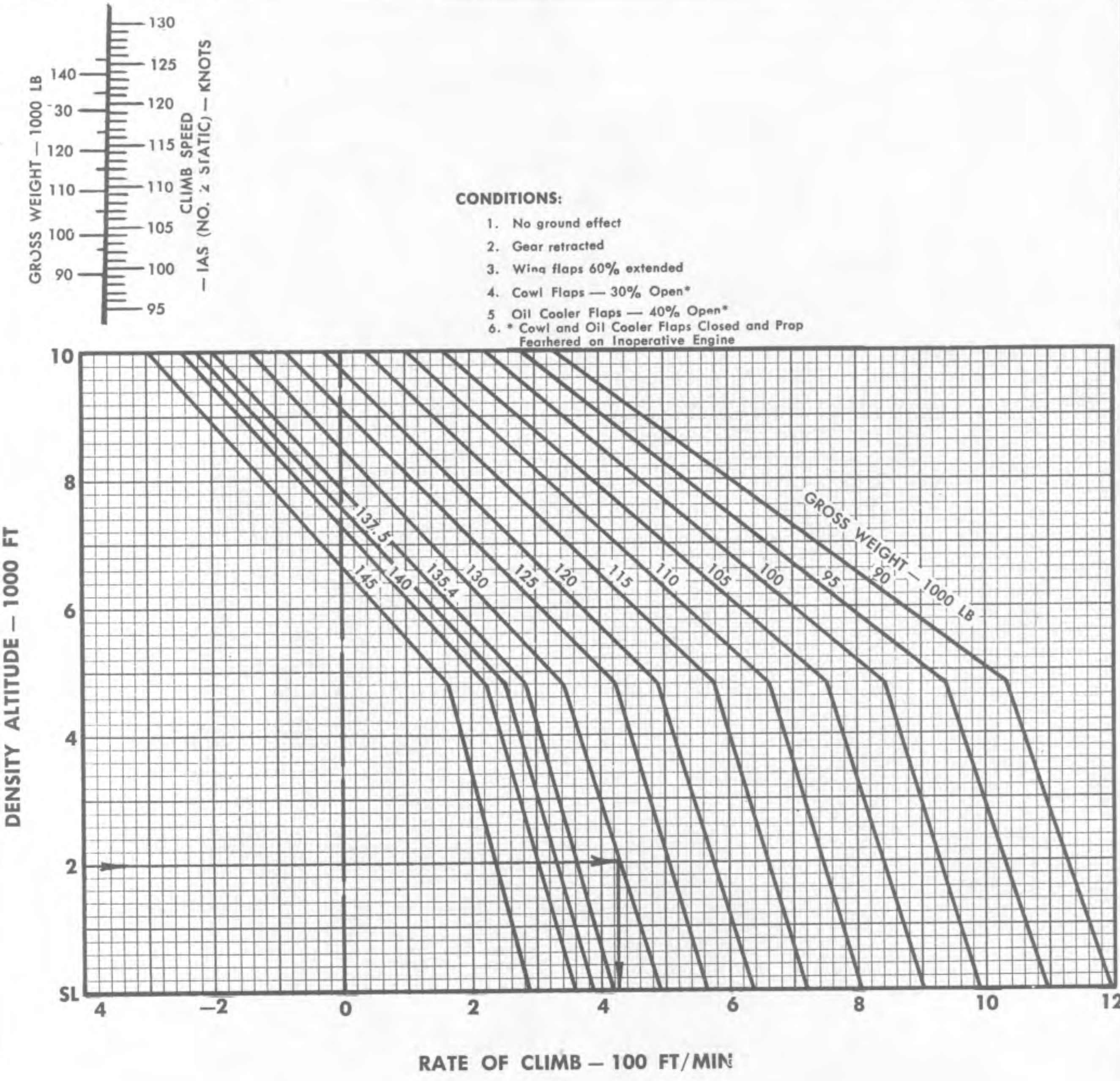
TAKEOFF RATE OF CLIMB

ALTERNATE METO POWER
GEAR UP

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



CONDITIONS:

1. No ground effect
2. Gear retracted
3. Wing flaps 60% extended
4. Cowl Flaps — 30% Open*
5. Oil Cooler Flaps — 40% Open*
6. * Cowl and Oil Cooler Flaps Closed and Prop Feathered on Inoperative Engine

Figure A3-18

THREE ENGINE OPERATION

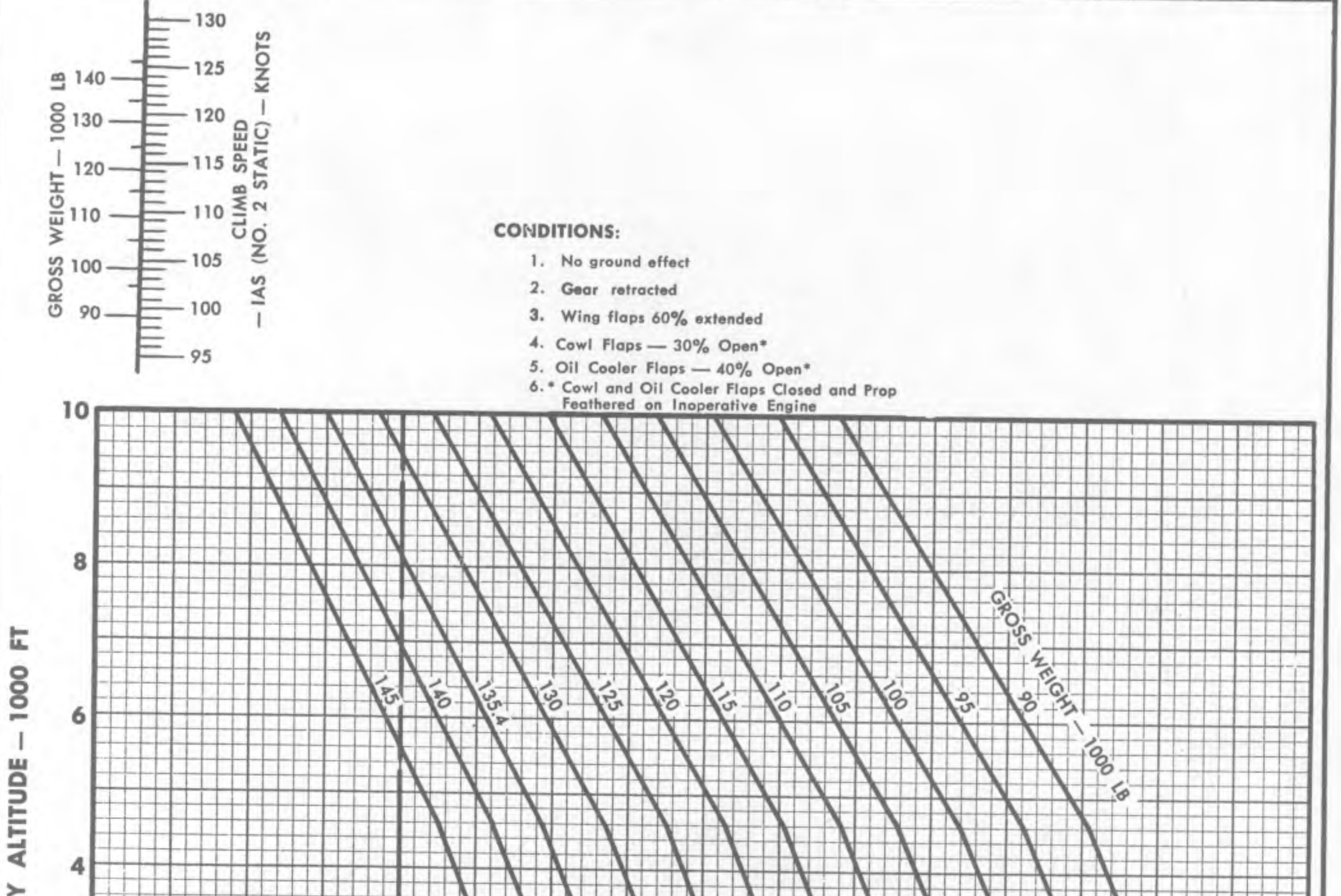
TAKEOFF RATE OF CLIMB

METO POWER
GEAR UP

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



CONDITIONS:

1. No ground effect
2. Gear retracted
3. Wing flaps 60% extended
4. Cowl Flaps — 30% Open*
5. Oil Cooler Flaps — 40% Open*
6. * Cowl and Oil Cooler Flaps Closed and Prop Feathered on Inoperative Engine

Figure A3-19

THREE ENGINE OPERATION
TAKEOFF WEIGHT AS LIMITED BY RUNWAY SLOPE
MAXIMUM POWER — 2900 RPM
GEAR DOWN

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL

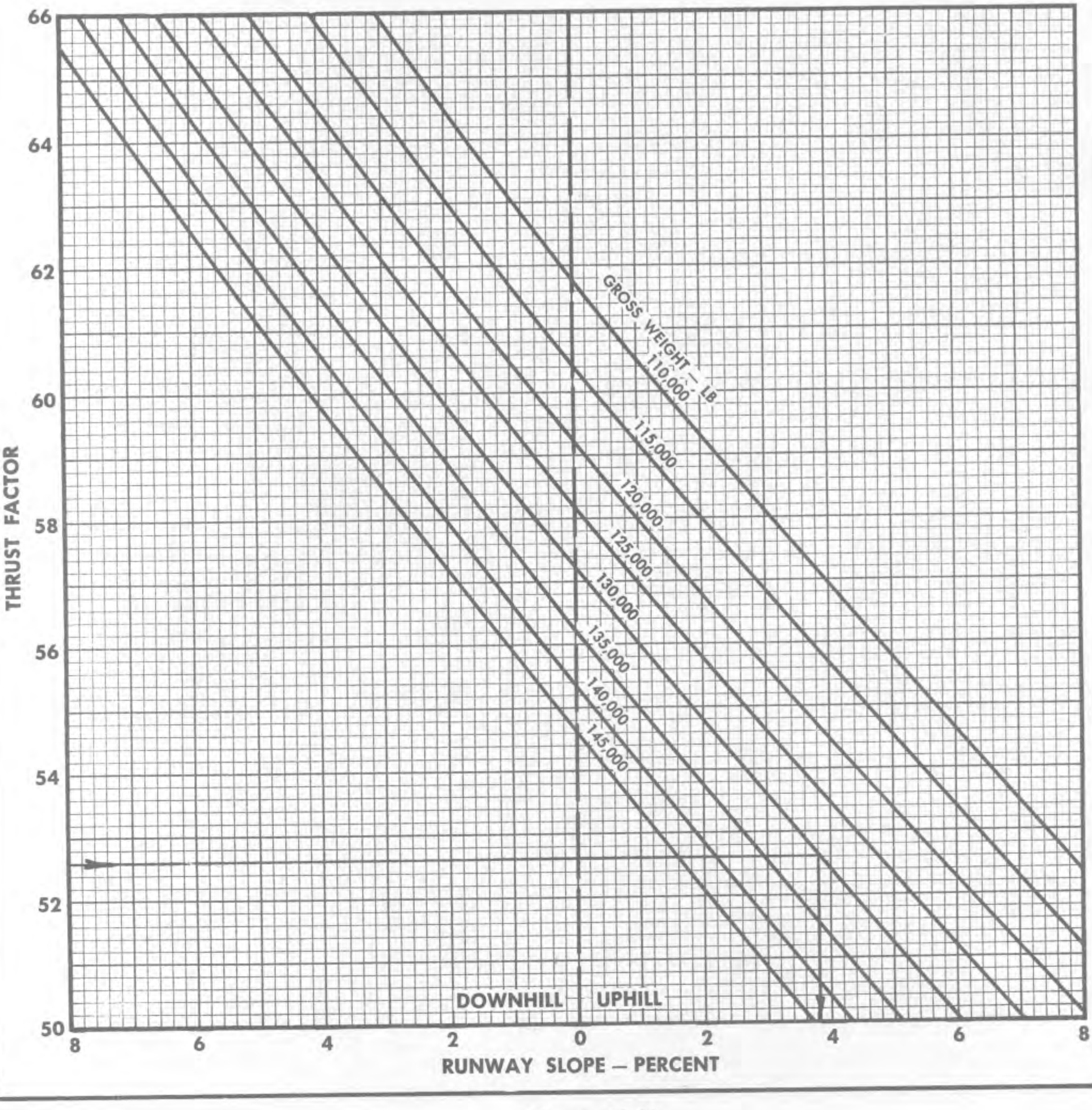


Figure A3-20

SLOPE EFFECT

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: CALCULATED

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL

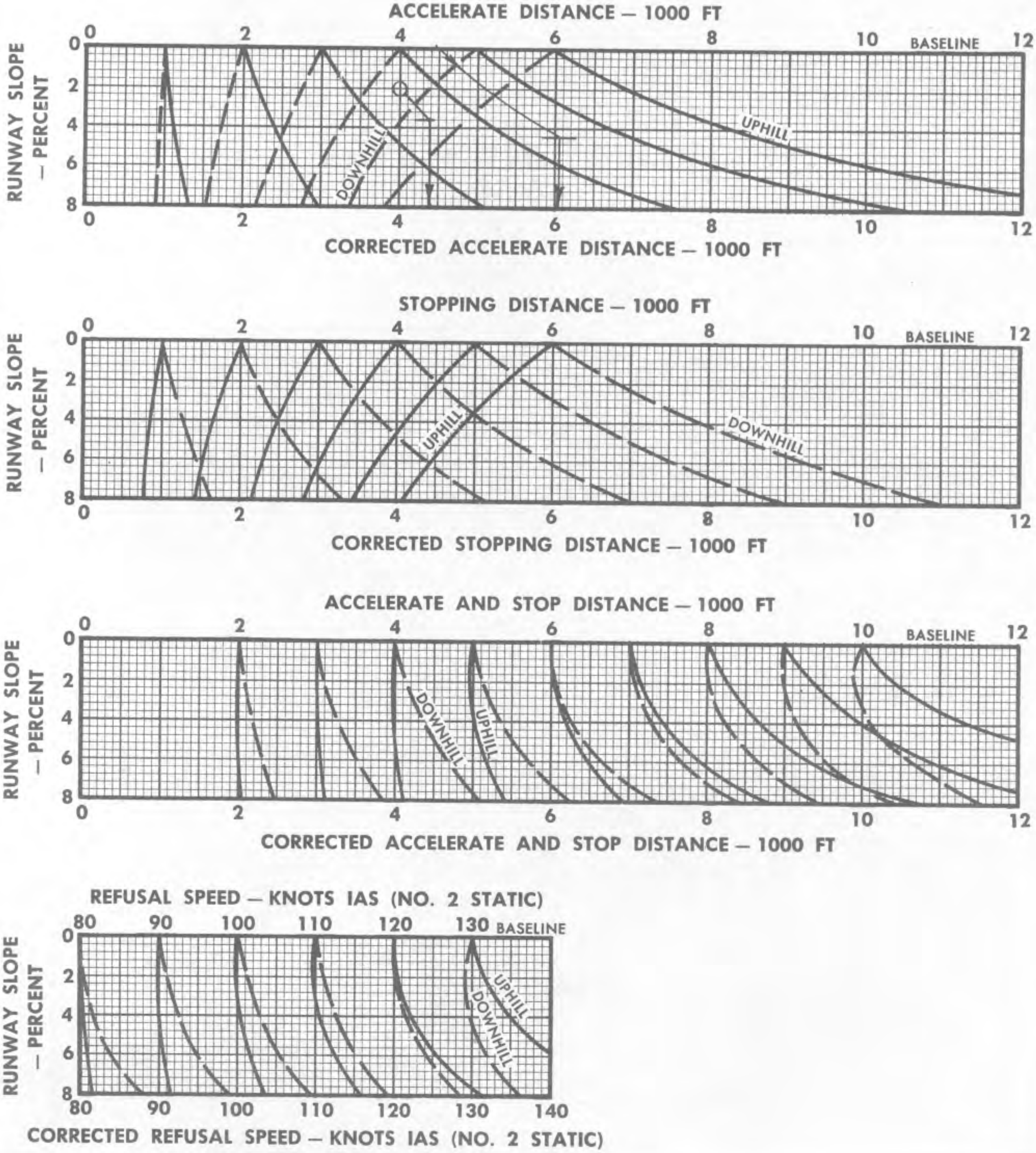


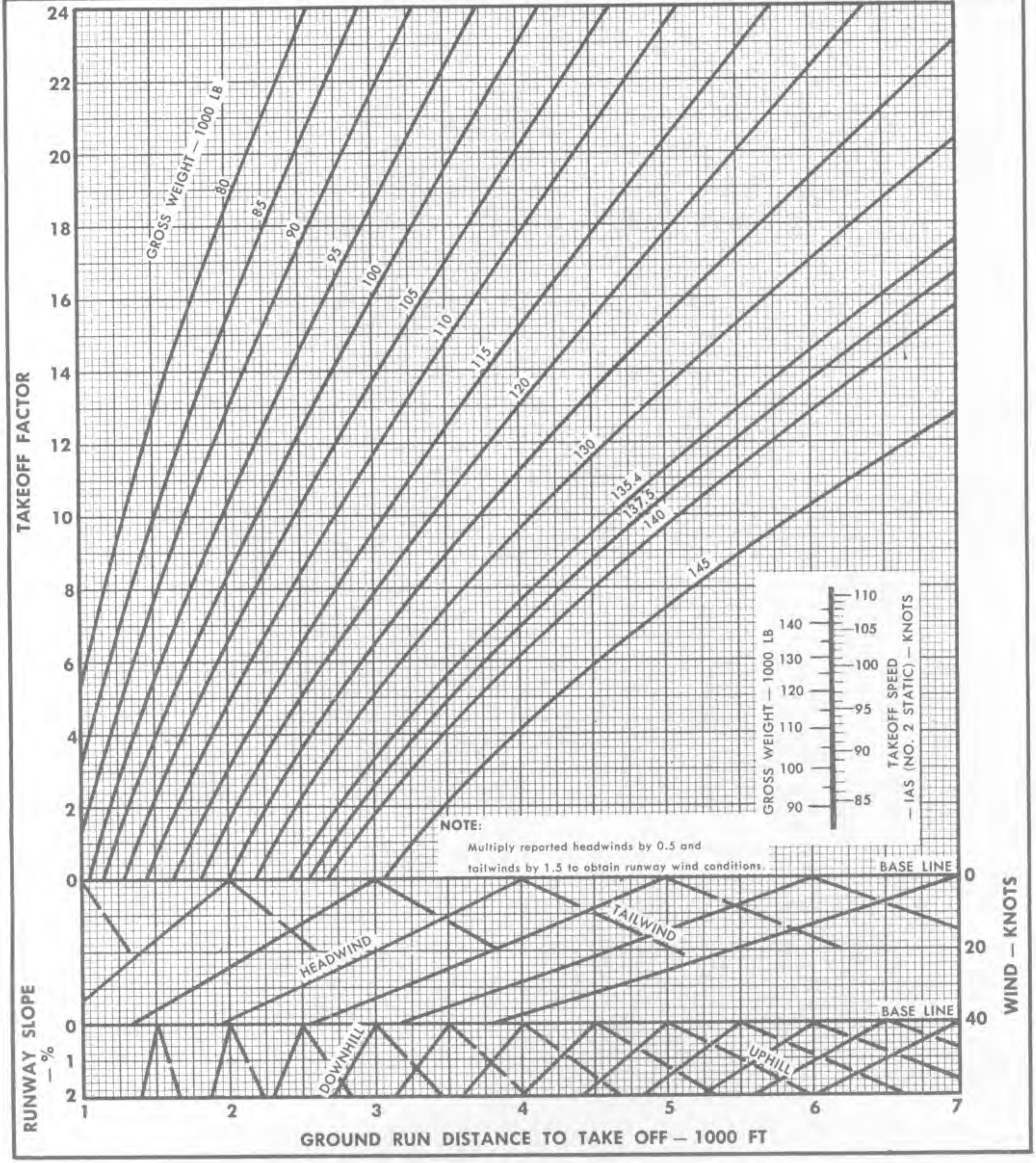
Figure A3-21

FOUR ENGINE OPERATION

MINIMUM DISTANCE TAKEOFF PERFORMANCE — GROUND RUN DISTANCE TO TAKE OFF

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O



NOTE:
Multiply reported headwinds by 0.5 and tailwinds by 1.5 to obtain runway wind conditions.

Figure A3-22

THREE ENGINE OPERATION

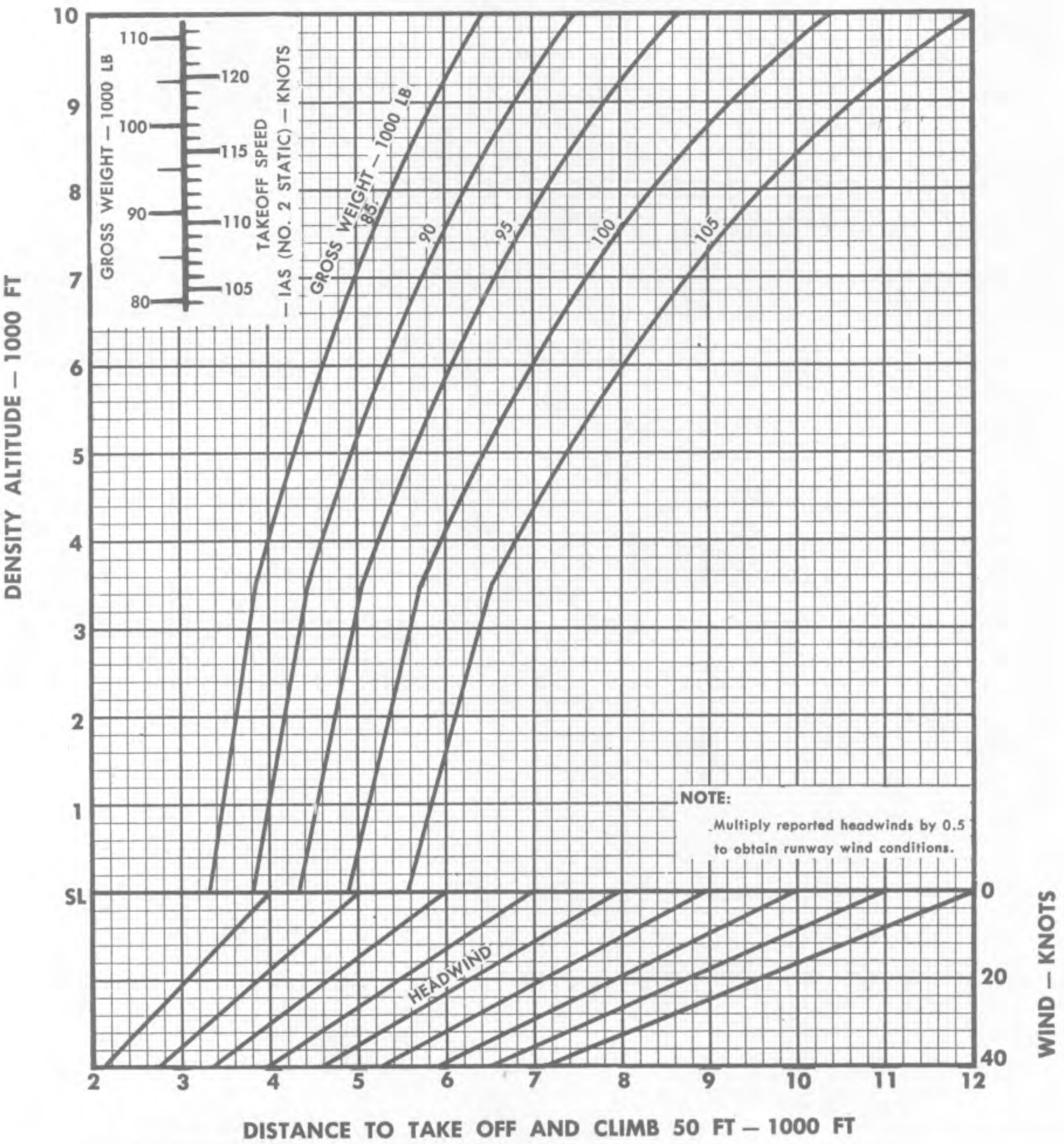
FERRYING CONFIGURATION TAKEOFF PERFORMANCE — DISTANCE TO TAKE OFF AND CLIMB 50 FT

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-O

CONDITIONS:

1. No ground effect
2. One propeller feathered or removed
3. Wing flaps 60% extended
4. Cowl flaps 30% open
5. Oil radiator flaps 40% open
6. All flaps closed on inoperative engine



NOTE:
Multiply reported headwinds by 0.5 to obtain runway wind conditions.

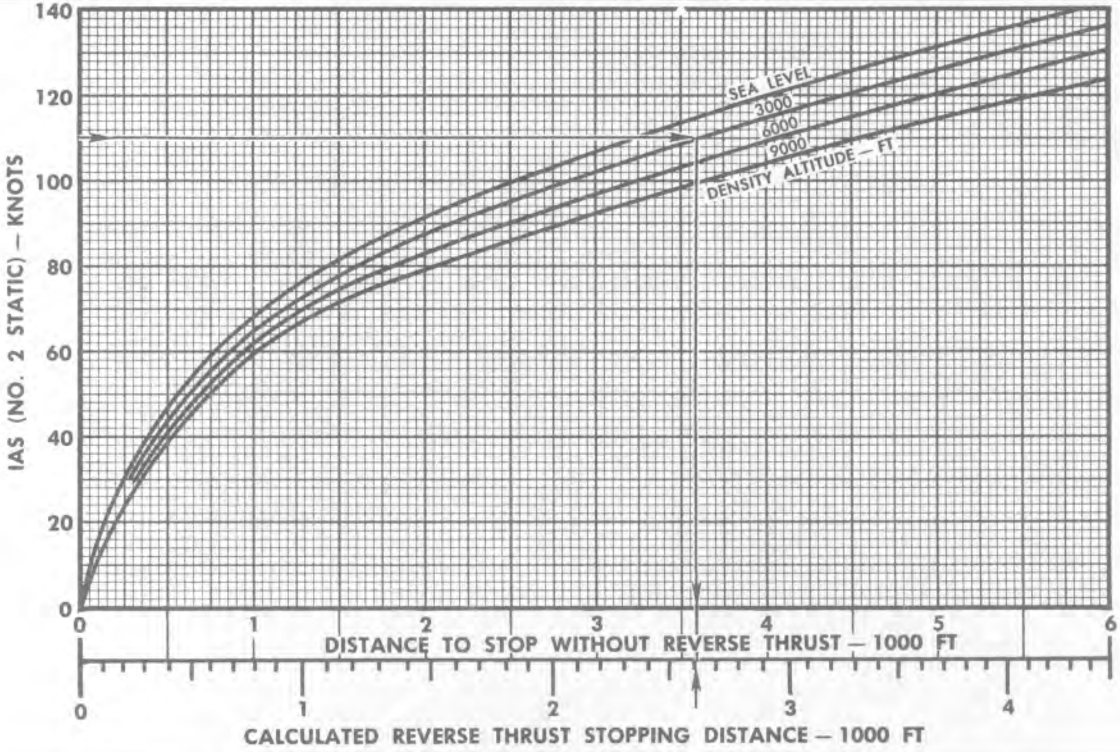
Figure A3-23

STOPPING DISTANCE

MODEL: EC-121R/C-121G
DATA AS OF: 31 MARCH 1967
DATA BASIS: FLIGHT TEST/ CALCULATED

ENGINE: (4) R3350-93A
PROPS: HAM. STD. 43H60/6959B-0

FUEL GRADE: 115/145
FUEL DENSITY: 6.0 LB/US GAL



CONDITIONS:

1. Wing flaps extended 60%.
2. Hard wheel braking.
3. Operative engine(s) idling.
4. Reverse thrust stopping distance assume symmetrical 2-engine reverse thrust at 2500 rpm with simultaneous brake application.
5. Multiply computed headwind component by 0.5 and computed tailwind by 1.5 to obtain effective runway wind component.
6. If no RCR is available, use 12 for wet runways and 5 for icy runways.

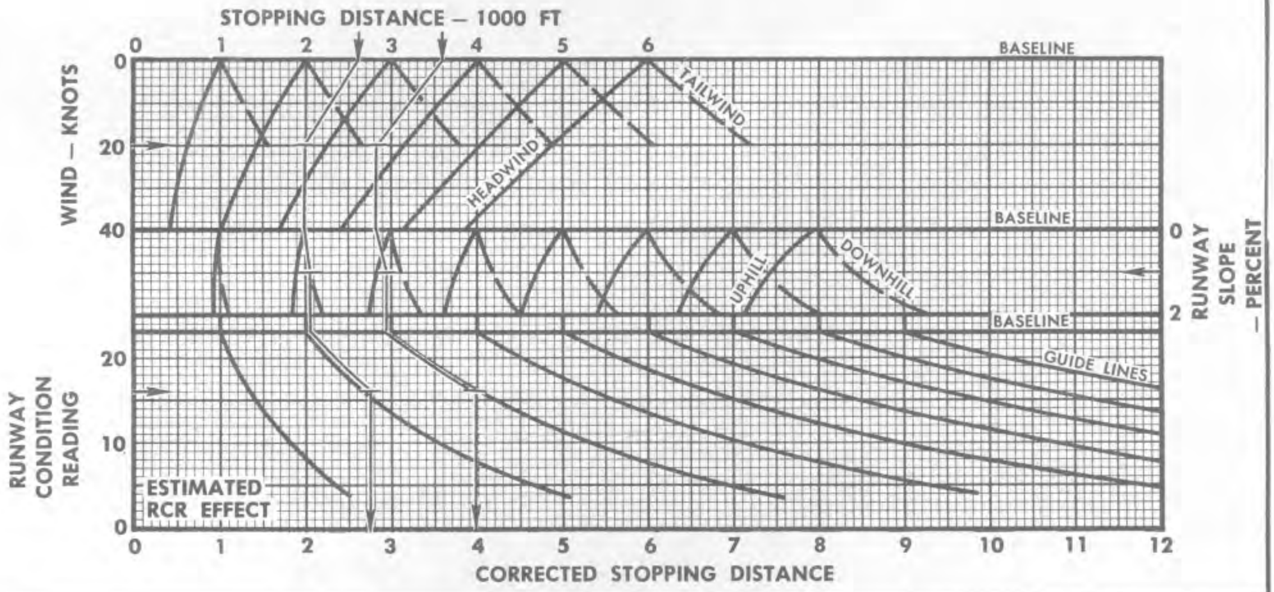


Figure A3-24