part 6 landing

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LIST OF ILLUSTRATIONS

LANDING.

DISCUSSION OF CHARTS.

Charts are included in this part to enable the pilot to determine the length of runway necessary to land the aircraft safely under various conditions of wind, temperature, altitude and runway surface. Since the length of the landing ground roll depends to a great extent on the coefficient of friction (μ'), numerical values of μ' are shown on the Landing Ground Roll chart *(figure A6-1)* corresponding to the most commonly encountered runway surface conditions.

The threshold and touchdown speeds found on the Characteristic Landing Speeds *(figure A6-2)* chart must be used in order to make good the determined landing distance. Headwind and crosswind components may be found by referring to figure A6-3.

LANDING GROUND ROLL CHART.

The Landing Ground Roll chart *(figure A6-1)* is used to determine the landing ground roll distance at various outside air temperatures, pressure and density altitudes (up to 14,000 feet), gross weights, actual headwind components, and runway surface conditions. The chart is based on the recommended approach and touchdown speeds obtained from the Characteristic Landing Speeds chart *(figure A6-2)*. This chart gives aircraft ground roll only; to compute landing distance from a 50-foot height, determine landing ground roll for prevailing runway surface conditions and to this add 30 percent of the landing ground roll for dry concrete runway surface. The sum of these two distances will give the approximate *total* landing distance from a 50-foot height. If it becomes necessary to land with wing flaps up, the landing ground roll will be increased approximately 21 percent. A sample problem is included on the chart.

CHARACTERISTIC LANDING SPEEDS CHART.

The Characteristic Landing Speeds chart *(figure A6-2)* presents the recommended threshold and touchdown speeds in knots IAS with 40 degrees flaps setting for various aircraft gross weights. Stall speeds for zero and 40 degrees flaps are included. A line labeled 110 percent of minimum control speed is plotted on the chart for planning purposes in the event a one-engine-out approach or three-engine go-around is necessary. Enter at the bottom of the chart at the planned approach/landing aircraft gross weight and proceed up vertically; intersect the recommended speed curves and read horizontally to the left the indicated airspeed in knots. A sample problem is included on the chart.

LANDING CROSSWIND CHART. -Deleted

MODEL: C-54 AND R5D
BASED ON ESTIMATED DATA
DATA AS OF 1-15-59

LANDING GROUND ROLL
WING FLAPS = 40 DEGREES

ENGINE(S): (4) R2000-4 AND-9M2

SAMPLE PROBLEM:

A. Outside air temperature = 30°C
B. Pressure altitude = 1500 feet
C. Gross weight = 63,700 pounds
D. Reported headwind = 15 knots
E. Ground roll distance on dry concrete = 1975 feet
F. Assume that $\mu' = 0.10$
G. Ground roll distonce for a μ' of 0.10 = 4350 feet
Air run = .30 × 1975 = 593 feet
Landing distance = 593 + 4350 = 4943 feet

NOTE:

1. Speed at 50 foot height = 130 percent of stall speed.
2. Speed at touchdown = 120 percent of stall speed.
3. Wing flaps = 40 degrees.
4. When landing with zero wing flap setting, increase ground roll distance by 21 percent.
5. μ' is the coefficient of rolling friction.
6. This chart is for londing ground roll distance only. Air run from o 50 foot height to touchdown is approximately 30 percent of landing ground roll on dry concrete for 40 degrees flap. Total landing distance from a 50 foot height is the sum of the air run plus the ground roll distance for any prevailing runway surface conditions.

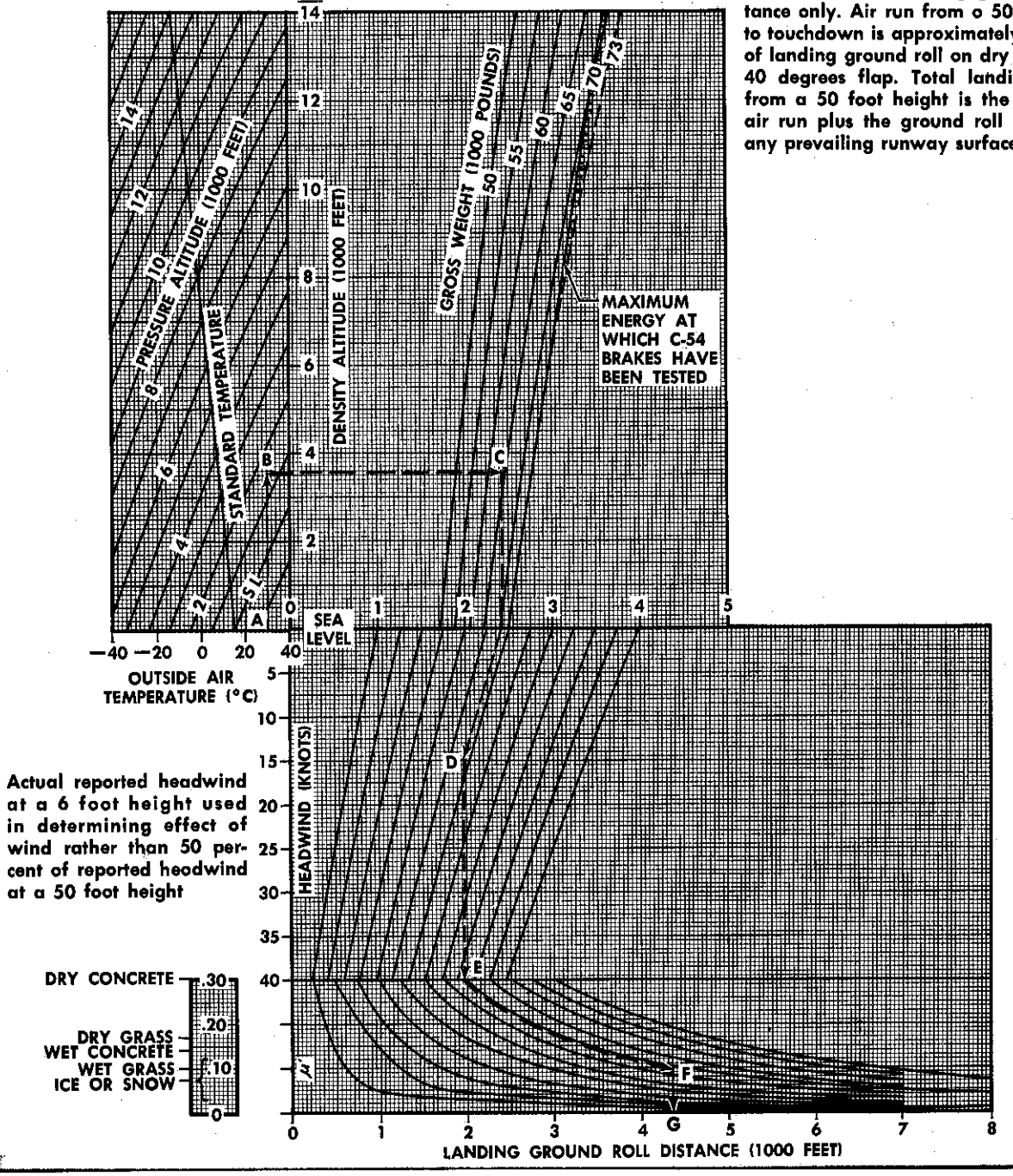

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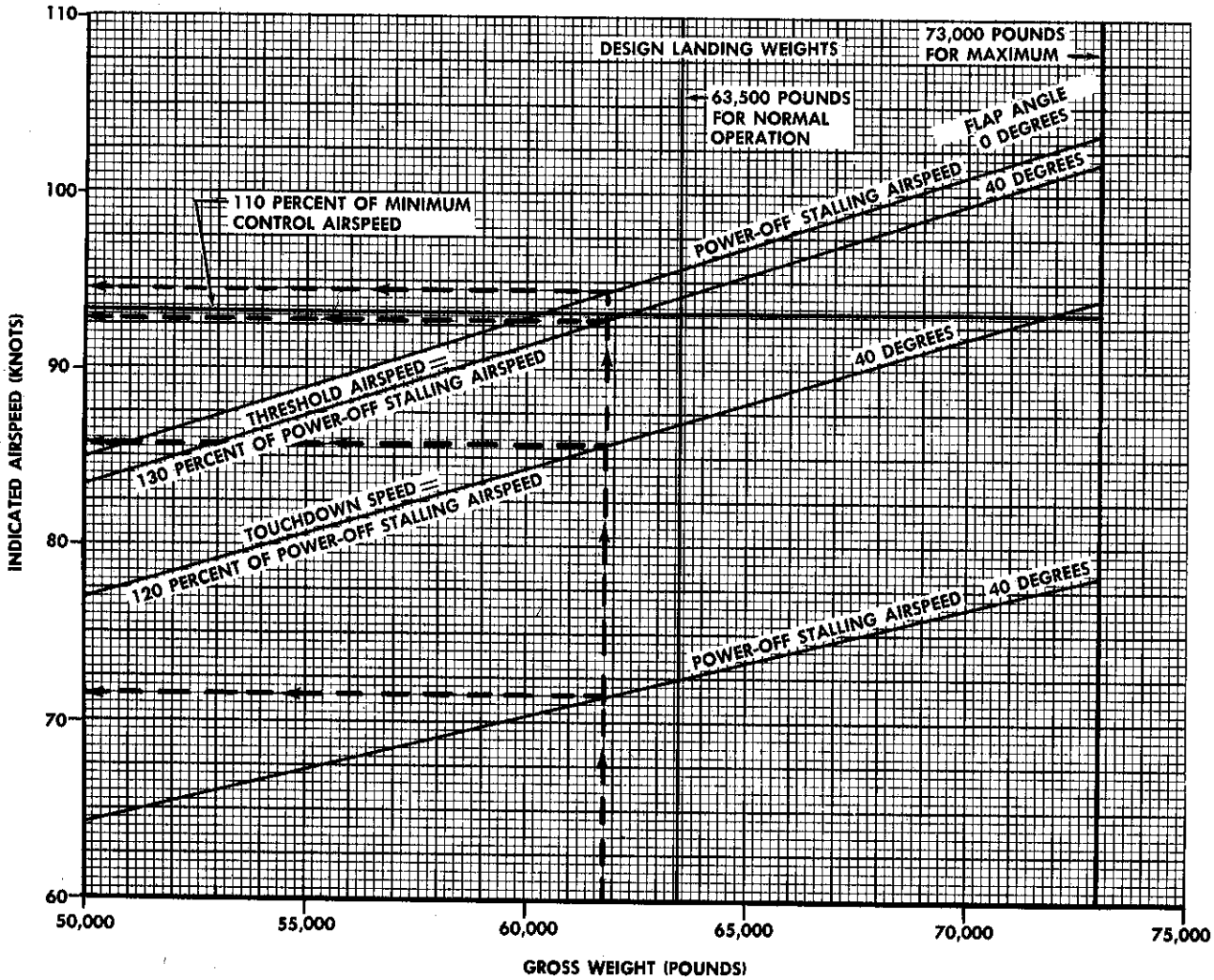
Figure A6-1. Landing Ground Roll — Wing Flaps 40 Degrees

CHARACTERISTIC LANDING SPEEDS

INDICATED AIRSPEED FOR AIRCRAFT WITH RADOME NOSE

MODEL: C-54 AND R5D

NOTES
1. For aircraft without radome nose subtract 1 knot.
2. Do not attempt three-engine go around at speeds below 110% of the minimum control speed.



BASED ON: FLIGHT TEST DATA
DATA AS OF: 1-15-59

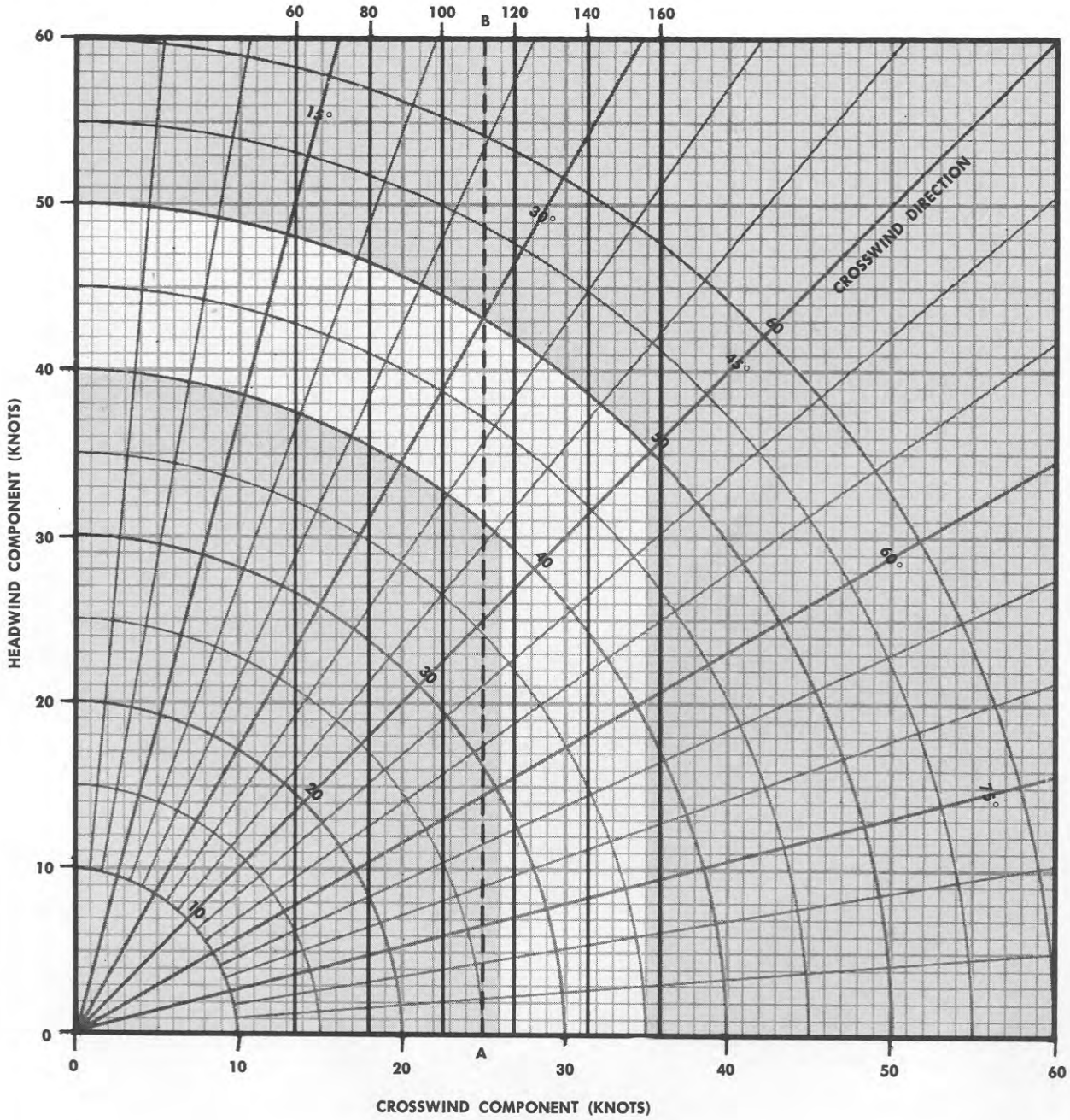
FUEL GRADE: 100/130
FUEL DENSITY: 6.0 LB/GAL

Figure A6-2. Characteristic Landing Speeds

Pages A6-5 and A6-6, figure A6-3 deleted.

LANDING CROSSWIND CHART

MINIMUM TOUCHDOWN SPEED (KNOTS)★



SAMPLE PROBLEM
LANDING RUNWAY — NORTH
WIND — 270° AT 25 KNOTS 90° CROSSWIND (POINT A)
RECOMMENDED TOUCHDOWN SPEED — 85 KNOTS IAS
CHART INDICATES
MINIMUM AIRSPEED 111 KNOTS (POINT B)
THEREFORE LANDING WITHOUT CRAB ANGLE MUST
BE ACCOMPLISHED AT 111 KNOTS
★ASSUMING NO CRAB ANGLE

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Figure A6-3. Landing Crosswind Chart

part 7
mission planning

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LIST OF ILLUSTRATIONS

MISSION PLANNING.

SAMPLE PROBLEMS.

Sample problems are presented to clarify the use of the performance charts when applied to a typical mission.

LONG-RANGE OPERATION.

Takeoff Conditions:

Pressure altitude ..... sea level

Outside air temperature ..... 19° C

Specific humidity 0.011

Headwind at 50-foot height (control tower) ..... 20 knots

Runway length available ..... 3500 feet

Runway slope ..... none

Takeoff Gross Weight:

Limited by Critical Field length *(figure A3-5)* ..... 73,000 pounds

Aircraft operating weight empty, including oil (gross weight less fuel and cargo) ..... 41,435 pounds

Climb and cruise conditions:

Cruise pressure altitude ..... 15,000 feet

Temperature ..... Standard Day

Headwind ..... zero

Total distance (long-range conditions, four-engine operation ..... 2000 nautical miles

Reserve fuel ..... 5 percent of total fuel carried (+ 30 minutes hold at sea level)

Determine takeoff abort criteria, the fuel and time required for flight, and the amount of cargo that can be carried:

1. Takeoff Abort Criteria.

Critical engine failure speed *(figure A3-5)* ..... 83 knots IAS

Ground Run — Four engines *(figure A3-2)* ..... 2500 feet

Takeoff speed *(figure A3-2)* ..... 102 knots IAS

Distance to critical engine failure speed ..... 1400 feet

Marker ..... 1000 feet

Acceleration check speed (no tolerance) ..... 76 knots IAS

2. Fuel for warmup and takeoff (10 minutes at METO power) ..... 710 pounds

$$\left(\frac{10}{60} \times 1200 \times 4 \times 0.888\right)$$

3. Climb at METO power (weight at start of climb) ..... 72,290 pounds

From METO power climb curves *(figures A4-1, and A4-2)*, the following is determined:

Distance to climb to 15,000 feet ..... 48 nautical miles

Time to climb to 15,000 feet ..... 19 minutes

Weight at end of climb ..... 71,100 pounds

Fuel burned in climb = weight at start of climb minus weight at end of climb ..... 1140 pounds

Distance remaining to be travelled ..... 1952 nautical miles

4. To determine the amount of fuel and time required for cruise flight: enter the long-range flight planning chart for 15,000 feet density altitude *(figure A5-24)* at 71,100 pounds and zero wind. Read range as 4100 nautical miles and time as 23.2 hours. Subtract the desired range, 1952 miles, from 4100 miles and re-enter the chart at 2148 nautical miles; final cruise gross weight = 59,000 pounds and time at that final cruise gross weight = 12.4 hours.

Cruising time = 23.2 — 12.4 = 10.8 hours

Total time of flight = 10.8 + .32 = 11.12 hours

$$\text{Average speed} = \frac{2000}{11.12} = 18.0 \text{ knots}$$

Total fuel consumed in flight (difference between 73,000 pounds takeoff weight and final cruise weight of 59,000 pounds) = 14,000 pounds.

5. To determine the power settings and speed for long-range cruise, enter the long-range power conditions curve *(figure A5-19)* at the instantaneous gross weight. At the initial cruise gross weight of 71,100 pounds, read:

Calibrated airspeed = 143.5 knots

Brake horsepower = 678

RPM = 1940

Manifold pressure = 29.6 in. Hg

Fuel flow = 1250 pounds per hour

Nautical miles per pound = 0.145

Note

The flight planning charts are based on long-range cruising operation; therefore, it is essential that conditions of the 99 percent maximum range power conditions curves be followed. Power settings should be changed at least every hour in order that range and time performance on the long-range prediction curves be attainable. The fuel flow data will facilitate the determination of the new gross weight at the time of the power change. At the end of one hour cruise at the initial power setting, the gross weight will be 71,100 pounds minus 1250 pounds or 69,850 pounds. New power settings can then be read at this new weight.

Note

The Specific Range charts *(figures A5-1 to A5-8)* may be used to check the results obtained from the Long-Range Power Condition chart *(figure A5-19)*. The recommended long-range speed for any cruise weight and corresponding power setting can be determined by following the 99 percent maximum range line on the graph.

6. To determine the amount of cargo that can be transported, the reserve fuel must be computed. The reserve fuel for this example equals 5 percent of total fuel carried plus 30 minutes at speed for long range at sea level.

To determine the fuel required for 30 minutes at long-range speed at sea level, enter the Four-Engine Long-Range Power Condition curve *(figure A5-19)*. Read the fuel flow at the landing weight at sea level:

Fuel for 30 minutes hold at 59,000 pounds at sea level = $30/60 \times 860 = 430$ pounds

Five percent of the total fuel carried =

$$0.05 \left(\frac{(73{,}000 \quad 59{,}000 \quad + \quad 430)}{.95}\right) = 760.$$

Total reserve fuel = 500 + 760 = 1,260 pounds

Note

The total fuel carried is equal to fuel used during warmup and takeoff plus fuel burned during climb, plus fuel burned during cruise, plus hold and reserve fuel.

The total fuel carried is equal to 15,260 pounds. The operating weight empty plus the total fuel carried is 41,435 + 15,260, or 56,695; the cargo carried is 73,000 — 56,695, or 16,305 pounds.

CONSTANT POWER OPERATION EXAMPLE.

Cruise Conditions:

Atmospheric condition ..... Standard Day

Headwind ..... 20 knots

Distance to be travelled (four-engine operation at 750 bhp/engine) ..... 1000 nautical miles

Cruising altitude ..... 10,000 feet

Aircraft operating weight empty, including oil (gross weight less fuel and cargo) ..... 41,435 pounds

Reserve fuel (long-range speed) ..... 3 hours at 10,000 feet

Takeoff and Landing Conditions:

Pressure altitude ..... sea level

Temperature ..... 24°C

Specific humidity 0.015

Headwind at 50 feet above runway ..... 20 knots

Runway length available ..... 5500 feet

Runway slope ..... + 0.012 (uphill)

Obstacle height above runway ..... 60 feet

Obstacle distance from end of runway ..... 3500 feet

Climb power ..... 33 in. MAP and 2300 rpm

Cargo ..... 19,265 pounds

Fuel for takeoff and warmup ..... 710 pounds

Landing pressure altitude ..... 1500 feet

Temperature ..... 30°C

Reported headwind ..... 15 knots

Landing runway surface ..... $\mu' = 0.10$

Determine the takeoff weight and the time required for flight:

1. To determine the reserve fuel, first solve for the landing weight less the reserve fuel. This is equal to the operating weight empty plus the cargo, 41,435 plus 19,265 which equals 60,700 pounds. Second, enter the long-range cruise chart for 10,000 feet *(figure A5-23)* at 60,700 pounds, and read the time as 14.8 hours. Add 3 hours to this and reenter the chart at 17.8

hours; read the gross weight as 63,700 pounds (this exceeds the design landing weight for normal operation by 200 pounds).

This is the landing weight or the weight at the end of cruise. To determine the required landing ground roll, enter the Landing Ground Roll chart *(figure A6-1)* at this weight and the reported conditions at the destination. Read landing ground roll = 4350 feet. Air run from 50-foot height = 0.3 × 1975, or 593 feet. Total distance from 50-foot height to end of ground roll = 4350 + 593 = 4943 feet.

2. Knowing the weight at end of cruise, the actual cruise distance is estimated to determine the weight at beginning of cruise. Assume that the climb distance is 50 nautical miles, leaving 950 nautical miles to be flown in cruise. Estimate cruise fuel = 7500 pounds. Average cruise weight = 63,700 + 7500/2 = 67,450. Enter the 10,000 Feet Specific Range chart at this weight and 750 bhp. Read nautical miles per pound = 0.146, true airspeed = 198 knots.

Correct miles per pound for headwind.

$$\frac{198 - 20}{198} \times 0.146 = 0.1312$$

$$\text{Cruise fuel} = \frac{950\text{NM}}{0.1312} = 7240 \text{ pounds.}$$

The gross weight at the start of cruise is then 63,700 plus 7,240, or 70,940 pounds. This is also the weight at the end of climb.

3. Entering the 2300 rpm and 33 in. MAP climb curves *(figures A4-3 and A4-4)* at 70,940 pounds, it is seen that the distance travelled in climb to 10,000 feet is 46 nautical miles, and the time required is 0.325 hour (19.5 minutes). It is assumed that an average of 75 percent of the headwind at 10,000 feet is encountered during the climb. This will decrease the climb distance by 0.75 × 0.325 × 20, or 5 nautical miles. The distance to climb is then 41 nautical miles. The distance in cruise is then 959 nautical miles (1000 — 41).

4. Now recheck the cruise fuel:

Cruise fuel = 959/.1312 = 7310 pounds

Initial cruise weight = 63,700 plus 7310, or 71,010 pounds

Cruise time = 959/(198-20) = 5.38 hours

5. Enter the climb chart now at 71,010 pounds at 10,000 feet. Read the distance travelled as 46 nautical miles (41 corrected for wind), the time as .325 hours (19.5 minutes), and the weight at start of climb as 71,700 pounds.

6. The takeoff weight equals 71,700 pounds plus 710 (takeoff and warmup fuel), or 72,410 pounds. The total flight time equals 5.38 hours plus .33, or 5.71 hours. The average ground speed is 1000/5.71, or 175 knots.

7. Before determining takeoff performance, check to see if the proposed takeoff weight is permitted by the takeoff conditions.

a. Structural limit for normal operation *(figure A3-11)* . . . . 73,000 pounds

b. Maximum takeoff weight based on three-engine climb capability at takeoff (50 feet per minute rate of climb, no ground effect, figure A3-1) . . . 76,500 pounds

c. Maximum takeoff weight based on runway slope and three-engine climb capability at takeoff (weight at which flight path slope at takeoff, with no ground effect, equals the runway slope, figure A3-1) . . . . . 72,800 pounds

The proposed takeoff weight of 72,410 pounds is less than any of the weights found in steps a, b, or c.

8. Check to make sure that the critical field length is less than the available runway length.

Critical field length for 72,410 pounds *(figure A3-5)*, is 4030 feet. This is less than the available runway length of 5500 feet.

9. To determine obstacle clearance, use the takeoff flight path chart to find height of takeoff path above obstacle. When runways have appreciable slope, as in this example, it is easier to adjust the horizontal position of the obstacle than to shift the appropriate flight path curve horizontally to the correct takeoff point.

a. Obtain the zerowind, zero-slope critical field length for 72,410 pounds *(figure A3-5)* . . . . . 4120 feet

b. Also obtain the zerowind critical field length with slope *(figure A3-5)* = 4530 feet.

c. Subtract the zerowind critical field length with slope from the zerowind, zero-slope critical field length to obtain the slope correction to field length = 410 feet.

d. Subtract the slope correction to field length from the obstacle distance to obtain an adjusted obstacle distance = 9000 — 410 = 8590 feet.

e. Enter the chart of Takeoff Path — Three Engines chart *(figure A3-10)*, with the zerowind, zero-slope critical field length and interpolate to determine at what height the flight path slope passes over the adjusted obstacle distance = 135 feet. Subtract the obstacle height to obtain the obstacle clearance margin = 135 — 60 = 75 feet.

10. Since the flight path will clear the obstacle by an adequate margin and the other gross weight limits are not exceeded, takeoff is permitted at the proposed gross weight of 72,410 pounds. Record the following data for 72,410 pounds.

a. Critical field length *(figure A3-5)* = 4030

b. Critical engine failure speed *(figure A3-5)* = 87 knots IAS

c. Takeoff speed *(figure A3-2)* = 101 knots IAS.

d. Flap retraction speed *(figure A3-11)* = 121 knots IAS.

11. If they are desired, the go-no-go marker distance and go-no-go speed may be determined as follows.

a. Obtain ground run *(figures A3-2 and A3-3)* = 2730 feet.

b. Subtract headwind from takeoff speed = 101 — 20 = 81 knots IAS.

c. Obtain refusal speed *(figure A3-6)* = 99 knots IAS.

d. Enter Speed During Ground Run chart *(figure A3-7)* with 2730 feet and 81 knots to establish a contour line.

e. Follow down contour to refusal speed, less the headwind (79 knots) and read the refusal distance = 2550 feet.

f. The nearest 1000-foot marker below the refusal distance is the go-no-go marker = 2000 feet.

g. Continue following down contour to the go-no-go marker distance and read the speed = 72 knots IAS.

h. Add the headwind to obtain the go-no-go speed = 72 + 20 = 92 knots IAS.

C-54 TAKEOFF DATA CARD

CONDITIONS

NAME OF AIRFIELD _____

RUNWAY: NO. 18, LENGTH 5500 FEET, SLOPE 0.012

PRESSURE ALTITUDE Sea Level FEET TEMPERATURE 75 °F, 24 °C

DEW POINT 70 °F, 21 °C, SPECIFIC HUMIDITY 0.015

WIND SPEED COMPONENTS: ALONG RUNWAY 20 KNOTS, CROSSWIND 10 KNOTS

GROSS WEIGHT 72,410 lb.

TAKEOFF PERFORMANCE

TAKEOFF GROUND RUN 2730 FEET CRITICAL FIELD LENGTH 4030 FEET

REFUSAL DISTANCE 2550 FEET REFUSAL SPEED 99 KNOTS IAS

GO-NO-GO MARKER 2000 FEET GO-NO-GO SPEED 92 KNOTS IAS

CRITICAL ENGINE FAILURE SPEED 87 KNOTS IAS

TAKEOFF SPEED 101 KNOTS IAS

WING FLAP RETRACTION SPEED 121 KNOTS IAS

LANDING PERFORMANCE IMMEDIATELY AFTER TAKEOFF

GROSS WEIGHT (NOT TO EXCEED 73,000 LB.) 71,700 POUNDS

LANDING ROLL 1910 FEET

AIR RUN FROM 50 FEET HEIGHT 573 FEET

TOTAL LANDING DISTANCE 2483 FEET

THRESHOLD SPEED 100 KNOTS IAS

TOUCHDOWN SPEED 93 KNOTS IA5

THREE ENGINE GO-AROUND

INITIAL *FLAP DEFLECTION* = NOT MORE THAN 30 DEGREES

INITIAL *AIRSPEED* = NOT LESS THAN (T.O. SPEED) 101 KNOTS IAS

Figure A7-1. Takeoff Data Card

C-54 LANDING DATA CARD

CONDITIONS

NAME OF AIRFIELD _____

RUNWAY: NO. 11, LENGTH 6000 FEET, SLOPE 0

DENSITY ALTITUDE 3550 FEET

WIND COMPONENTS: ALONG RUNWAY 15 KNOTS, CROSSWIND 5 KNOTS

GROSS WEIGHT 63,700 POUNDS

PERFORMANCE

LANDING ROLL 4350 FEET

AIR RUN FROM 50 FEET HEIGHT 593 FEET

TOTAL LANDING DISTANCE 4943 FEET

THRESHOLD SPEED 94 KNOTS IAS

TOUCHDOWN SPEED 88 KNOTS IAS

THREE ENGINE GO-AROUND

INITIAL *FLAP DEFLECTION* = NOT MORE THAN 30 DEGREES

INITIAL *AIRSPEED* = NOT LESS THAN (T.O. SPEED) 96 KNOTS IAS

Figure A7-2. Landing Data Card

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Italics indicate illustrations.

A (Cont'd)

B

C

Italics indicate illustrations.

C (Cont'd)

D

Italics indicate illustrations.

Italics indicate illustrations.

Italics indicate illustrations.

Italics indicate illustrations.

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M

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S (Cont'd)

T

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