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Section 1 General Notes

1 Introduction

1.1 The data sheets in this manual are produced to support training and examinations in JAR-FCL Subject 031 - Mass and Balance for Aeroplanes.

1.2 The data contained within these sheets are for **training and examination purposes only**. The data must not be used for any other purpose and, specifically, **are not to be used for the purpose of planning activities associated with the operation of any aeroplane in use now or in the future**.

2 Aircraft Description

2.1 The aeroplanes used in these data sheets are of generic types related to the classes of aeroplane on which the appropriate examinations are based.

2.2 Candidates must select the correct class of aeroplane for the question being attempted.

Generic Aeroplanes

Single-Engine Piston	certificated under CS 23 (Light Aeroplanes)	
	Performance Class B	**SEP1**
Multi-Engine Piston	certificated under CS 23 (Light Aeroplanes)	
	Performance Class B	**MEP1**
Medium-Range Jet Transport	certificated under CS 25 (Large Aeroplanes)	
	Performance Class A	**MRJT1**

2.3 The same set of generic aeroplanes will be utilised in the following subjects:

- 031 - Mass and Balance - Aeroplanes
- 032 - Performance - Aeroplanes
- 033 - Flight Planning and Monitoring - Aeroplanes

3 Layout of Data Sheets

3.1 Each set of data sheets will consist of an introduction that will contain some pertinent information relating to the aircraft and the subject being examined. This data will include (but not be limited to) a list of abbreviations and some conversion factors.

3.2 This will be followed by a selection of graphs and/or tables that will provide coverage suitable for the syllabus to be examined. A worked example will accompany each graph/table and will demonstrate typical usage.

4 Definitions

Definitions given in italics are not given in ICAO, or JAA or EASA documentation but are in common use.

4.1 **Mass Definitions:**

Basic Empty Mass (Basic Mass)	*is the mass of an aeroplane plus standard items such as: unusable fuel and other unusable fluids; lubricating oil in engine and auxiliary units; fire extinguishers; pyrotechnics; emergency oxygen equipment; supplementary electronic equipment.*
Dry Operating Mass (DOM)	is the total mass of the aeroplane ready for a specific type of operation excluding usable fuel and traffic load. The mass includes items such as: i) Crew and crew baggage. ii) Catering and removable passenger service equipment. iii) Potable water and lavatory chemicals. iv) Food and beverages.
Maximum Structural Landing Mass (MSLM)	the maximum permissible total aeroplane mass on landing in normal circumstances.
Maximum Structural Take-Off Mass (MSTOM)	the maximum permissible total aeroplane mass at the start of the take-off run.
Maximum Structural Taxi Mass	*is the structural limitation of the mass of the aeroplane at commencement of taxi.*
Maximum Zero Fuel Mass (MZFM)	is the maximum permissible mass of an aeroplane with no usable fuel.
Operating Mass (OM)	*is the DOM plus fuel but without traffic load.*
Performance Limited Landing Mass (PLLM)	*is the mass subject to the landing aerodrome limitations.*
Performance Limited Take-Off Mass (PLTOM)	*is the take-off mass subject to departure aerodrome limitations.*

Regulated Landing Mass (RLM)	*is the lowest of the 'performance limited' landing mass and 'structural limited' landing mass.*
Regulated Take-Off Mass (RTOM)	*is the lowest of the 'performance limited' TOM and 'structural limited' TOM.*
Take-Off Mass (TOM)	is the mass of the aeroplane including everything and everyone contained within it at the start of the take-off run.
Taxi Mass	*is the mass of the aeroplane at the start of the taxi (at departure from the loading gate). Sometimes referred to as Ramp Mass.*
Traffic Load	is the total mass of passengers, baggage and cargo, including any 'non-revenue' load.
Useful Load	*is the total mass of the passengers, baggage and cargo, including any non-revenue load and usable fuel.* *It is the difference between the Dry Operating Mass and the Take-Off Mass.*
Zero Fuel Mass (ZFM)	*is DOM plus traffic load but excluding fuel.*

4.2 **Other Definitions**

Balance Arm (BA)	is the distance from the datum to the centre of gravity of a mass.
Centre of Gravity (CG)	is that point through which the force of gravity is said to act on a mass.
Datum	(relative to an aeroplane) is that point on the longitudinal axis (or extension thereof) from which the centres of gravities of all masses are referenced.
Dry Operating Index (DOI)	is the index for the position of the centre of gravity at Dry Operating Mass.
Loading Index (LI)	is a non-dimensional figure that is a scaled down value of a moment. It is used to simplify mass and balance calculations.
Moment	is the product of the mass and the balance arm

5 Conversions

All conversions are taken from ICAO Annex 5.

5.1 Mass Conversions

Pounds (lb) to Kilograms (kg)	lb x 0.454
Kilograms (kg) to Pounds (lb)	kg x 2.205

5.2 Volumes (Liquid)

Imperial Gallons to Litres (l)	Imp. Gall x 4.546
US Gallons to Litres (l)	US Gall x 3.785

5.3 Lengths

Feet (ft) to Metres (m)	ft x 0.305

5.4 Distances

Nautical mile (NM) to metres (m)	NM x 1852.0

6 Standard Mass Values

Mass Values for Passengers: 20 Passenger Seats or more

Passenger seats	20 or more		30 or more
	Male	Female	All Adult
All flights except holiday charters	88 kg	70 kg	84 kg
Holiday charters	83 kg	69 kg	76 kg
Children	35 kg	35 kg	35 kg

Mass Values for Passengers: 19 Passenger Seats or less

Passenger seats	1-5	6-9	10-19
Male	104 kg	96 kg	92 kg
Female	86 kg	78 kg	74 kg
Children	35 kg	35 kg	35 kg

Mass Values for Baggage: 20 Passenger Seats or more

Type of Flight	Baggage Standard Mass
Domestic	11 kg
Within the European Region	13 kg
Intercontinental	15 kg
All other	13 kg

NOTE: The masses above are subject to change. Candidates should therefore regard these as accurate for examination purposes only. For operational purposes refer to JAR-OPS 1.

Section 2 Data for Single-Engine Piston Aeroplane (SEP1)

1 Aeroplane Description and Data

- Monoplane
- Single reciprocating engine
- Propeller - constant speed
- Retractable undercarriage
- Performance Class B

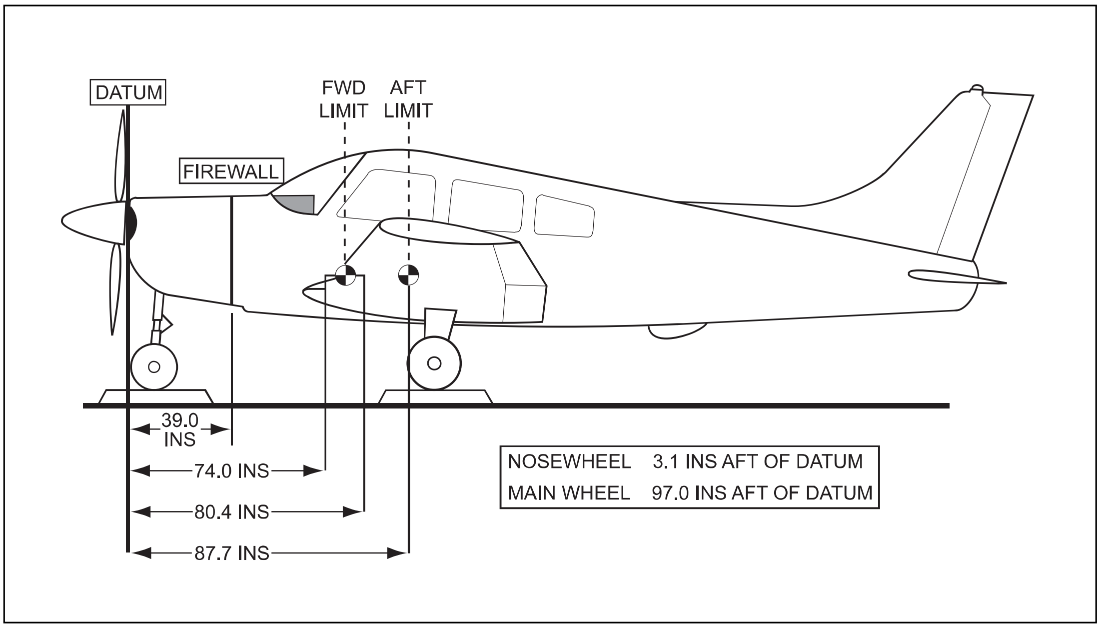
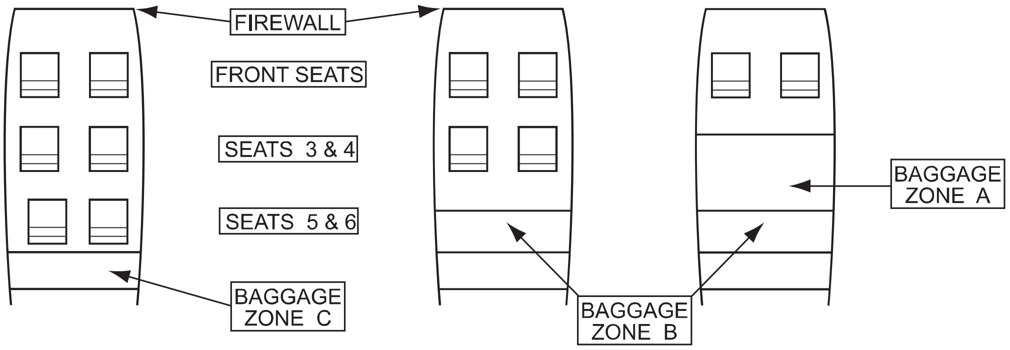


Figure 2.1 Location Diagram

Reference datum	39.00 inches forward of firewall
Centre of Gravity (CG) limits	forward limit 74.00 - 80.4 in aft limit 87.7 in
MSTOM MSLM	3,650 lb 3,650 lb
BEM	2,415 lb
BEM CG location	77.7 in
BEM Moment ÷ 100 =	1,876.46 in.lbs
Landing Gear retraction/extension	does not significantly affect CG position
Floor structure load limit	50 lb per square foot between front and rear spars (includes Baggage Zone A) 100 lb per square foot elsewhere (Baggage Zones B & C)



BAGGAGE/LOAD ZONE	ARM (INCHES)
A	108
B	150
C	180

Figure 2.2 Seating and Baggage Arrangements

Leading Edge Tanks (Fuel Tank Centroid Arm=75 in Aft of Datum)					
Gallons	**Weight (lb)**	**Moment ÷ 100 (in. lbs)**	**Gallons**	**Weight (lb)**	**Moment ÷ 100 (in. lbs)**
5	30	22.5	44	264	198
10	60	45	50	300	225
15	90	67.5	55	330	247.5
20	120	90	60	360	270
25	150	112.5	65	390	292.5
30	180	135	70	420	315
35	210	157.5	74	444	333
40	240	180			

Figure 2.3 Useful Mass and Moments of Usable Fuel

2 Procedure for Mass and Balance Calculation

(Refer to Figure 2.4)

2.1 Record the Basic Empty Mass and moment in the Basic Empty Condition row. The moment must be divided by 100 to correspond to 'Useful Mass and Moments table'.

2.2 Record the Mass and corresponding moment for each of the useful load items (except fuel) to be carried in the aeroplane (occupants, baggage).

2.3 Total the Mass column and moment column. The SUB-TOTAL is the Zero Fuel Condition

2.4 Determine the Mass and corresponding moment for the fuel loading to be used. This fuel loading includes fuel for the flight, plus that required for start, taxi and take-off. Add the Fuel to Zero Fuel Condition to obtain the SUB-TOTAL Ramp Condition.

2.5 Subtract the fuel to be used for start, taxi and run-up to arrive at the SUB-TOTAL Take-off Condition.

2.6 Subtract the Mass and moment of the fuel in the incremental sequence in which it is to be used from the take-off weight and moment. The Zero Fuel Condition, the Take-off Condition and the Landing Condition moments must be within the Centre of Gravity envelope at Figure 2.5.

2.7 If the total moment is less than the minimum moment allowed, useful load items must be shifted aft or forward load items reduced. If the total moment is greater than the maximum moment allowed, useful load items must be shifted forward or aft load items reduced. If the quantity or location of load items is changed, the calculations must be revised and the moments re-checked.

Item	Mass	Arm (in)	Moment ÷ 100
1. Basic Empty Condition			
2. Front Seat Occupants		79	
3. Third and Fourth Seat PAX		117	
4. Baggage Zone 'A'		108	
5. Fifth And Sixth Seat PAX		152	
6. Baggage Zone 'B'		150	
7. Baggage Zone 'C'		180	
Sub-total = Zero Fuel Mass			
8. Fuel Loading			
Sub-total = Ramp Mass			
9. Subtract Fuel for Start, Taxi and Run Up (see Note)			
Sub-total = Take-off Mass			
10. Trip Fuel			
Sub-total = Landing Mass			

NOTE: Fuel for start taxi and run up is normally 13 lb at an average entry of 10 in the column headed **Moment (÷ 100)**

Figure 2.4 Blank Loading Manifest SEP1

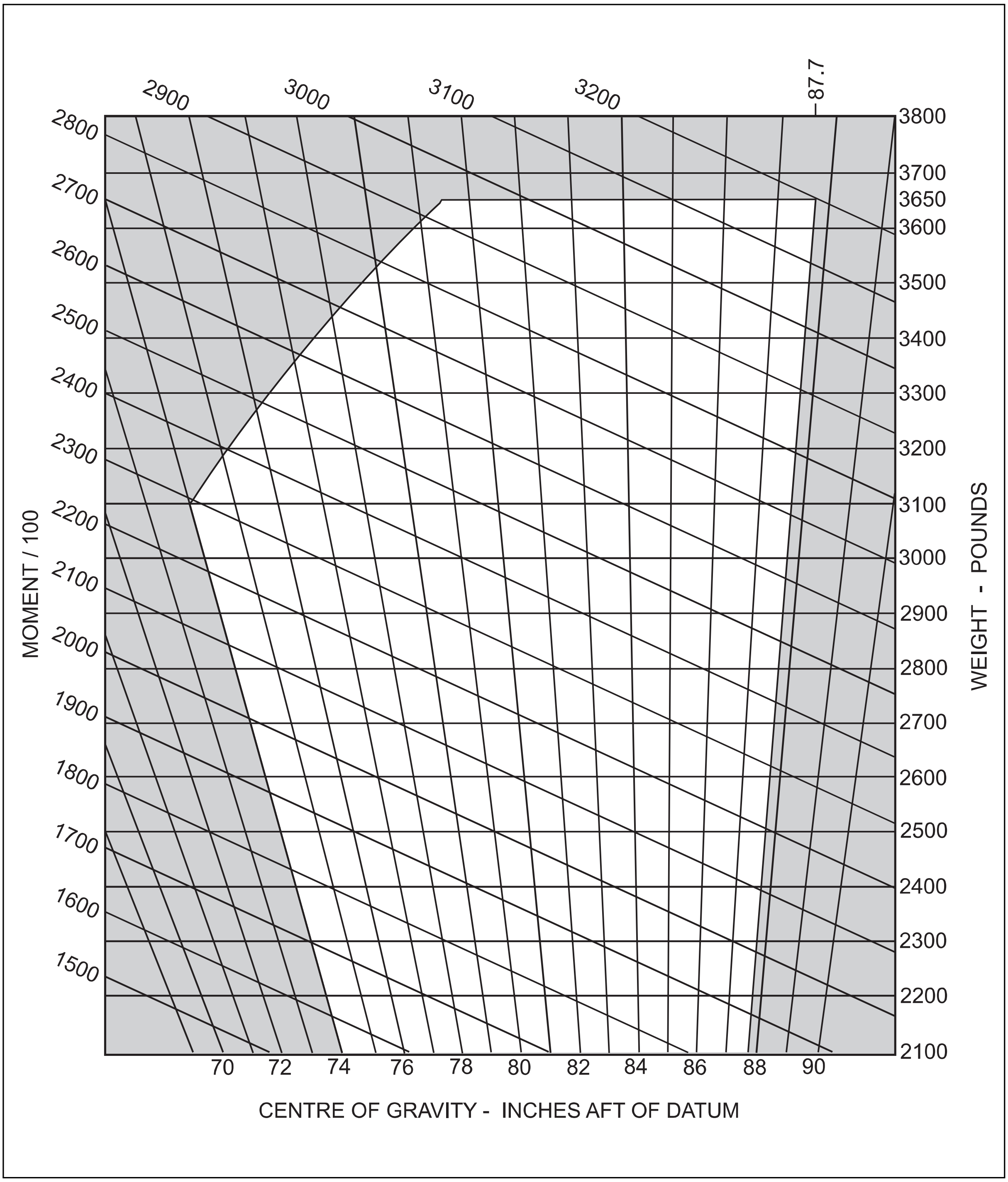


Figure 2.5 Blank Centre of Gravity Envelope

Section 3 Data for Light Twin-Engine Piston Aeroplane (MEP1)

1 Aeroplane Description and Data

1.1 Description

- Monoplane
- Twin reciprocating supercharged engines
- Counter- rotating, constant speed propellers
- Retractable undercarriage
- Performance Class B

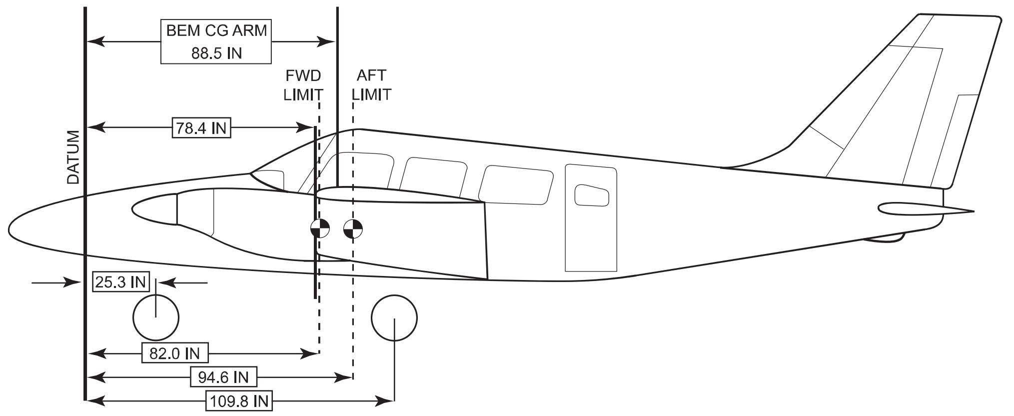


Figure 3.1 Location Diagram

Reference datum	78.4 inches forward wing leading edge at inboard edge of inboard fuel tank
CG limits fwd	82.0 inches to 90.8 inches (subject to aeroplane mass)
aft	94.6 inches
MSTOM	4,750 lb
MSLM	4,513 lb
MZFM	4,470 lb
BEM	3,210 lb
BEM CG location	88.5 inches
BEM Moment ÷ 100 =	2840.9 in.lbs

Gear retraction/extension does not **significantly** affect CG position

Structural Floor Loading Limit 120 lb/square foot

2 Configuration Options

2.1 Baggage/Freight Zones

	Max Mass	Arm	
Zone 1	100 lb	22.5	
Zone 2	360 lb	118.5	available **only** with centre seats removed
Zone 3	400 lb	157.6	available **only** with rear seats removed
Zone 4	100 lb	178.7	

2.2 Standard Allowances

2.2.1 Fuel relative density - an average mass of 6 lb per US gallon should be used. Passenger and pilot mass - actual mass values should be used.

3 Procedure for Mass and Balance Calculations

See example at Figures 3.2 and 3.3. Figures 3.4 and 3.5 are provided for your use.

a) Enter all mass values in correct locations on table (Figure 3.2/3.4)

b) Calculate moments for each entry

c) Total mass values to obtain zero fuel mass

d) Total moments for zero fuel mass condition

e) Determine arm at zero fuel mass

f) Add total fuel mass and arm

g) Obtain moment for fuel load

h) Add fuel mass and moment to determine ramp mass and moment

i) Deduct start-up, taxi and run-up fuel allowance and correct moment to obtain take-off conditions.

j) Check CG position lies within envelope (chart at Figure 3.3/3.5)

k) Deduct estimated fuel burn to destination

l) Obtain estimated landing mass and moment

m) Check CG position at landing to ensure that it lies within envelope (chart at Figure 3.3/3.5)

ITEM	Mass (lb)	Arm Aft of Datum (in)	Moment ÷ 100 (in.lbs)
Basic Empty Mass	3,210	88.5	2,840.85
Pilot and Front Passenger	340	85.5	290.7
Passengers (Centre Seats) or Baggage Zone 2 (360 lb max)	236	118.5	279.66
Passengers (Centre Seats) or Baggage Zone 3 (400 lb max)	340	157.6	535.84
Baggage Zone 1 (100 lb max)	100	22.5	22.5
Baggage Zone 4 (100 lb max)	N/A	178.7	NIL
Zero Fuel Mass (4,470 lb max)	4,226	93.9	3969.55
Fuel (123 US gallons Max)	545	93.6	510.12
Ramp Mass (4,773 lb max)	4,771	93.9	4479.67
Fuel Allowance for Start, Taxi Run-up	-23	93.6	-21.53
Take-off Mass (4,750 lb max)	4,748	93.9	4458.14
Minus Estimated Fuel Burn-off	-450	93.6	-421.2
Landing Mass (4,513 lb max)	4,298	93.9	4036.94

NOTE: Maximum mass values given in this table are for **structural limits only.**

Figure 3.2 Example Loading Manifest MEP1

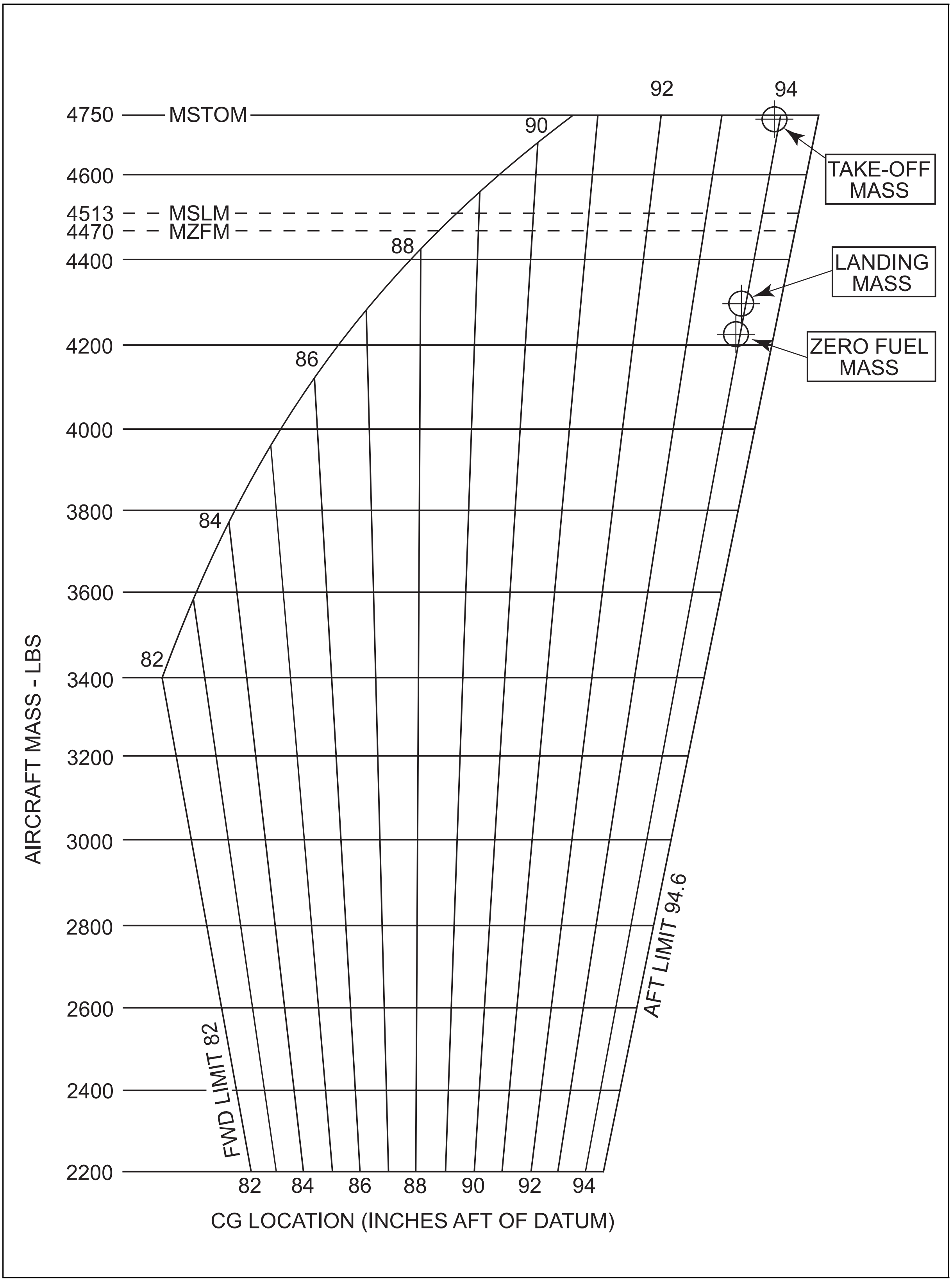


Figure 3.3 Example Centre of Gravity Envelope

ITEM	Mass (lbs)	Arm Aft Of Datum (in)	Moment ÷ 100 (in.lbs)
Basic Empty Mass	3210	88.5	
Pilot and Front Passenger		85.5	
Passengers (Centre Seats) or Baggage Zone 2 (360 lb Max.)		118.5	
Passengers (Rear Seats) or Baggage Zone 3 (400 lb Max.)		157.6	
Baggage Zone 1 (100 lb Max.)		22.5	
Baggage Zone 4 (100 lb Max.)		178.7	
Zero Fuel Mass (4,470 lb Max - Std)			
Fuel (123 gal. Max.)		93.6	
Ramp Mass (4,773 lb Max)			
Fuel Allowance for Start, Taxi, Run-up		93.6	
Take-off Mass (4,750 lb Max.)			
Minus Estimated Fuel Burn-off		93.6	
Landing Mass (4,513 lb Max.)			

NOTE: Maximum mass values given in this table are for structural limits only.

Figure 3.4 Blank Loading Manifest

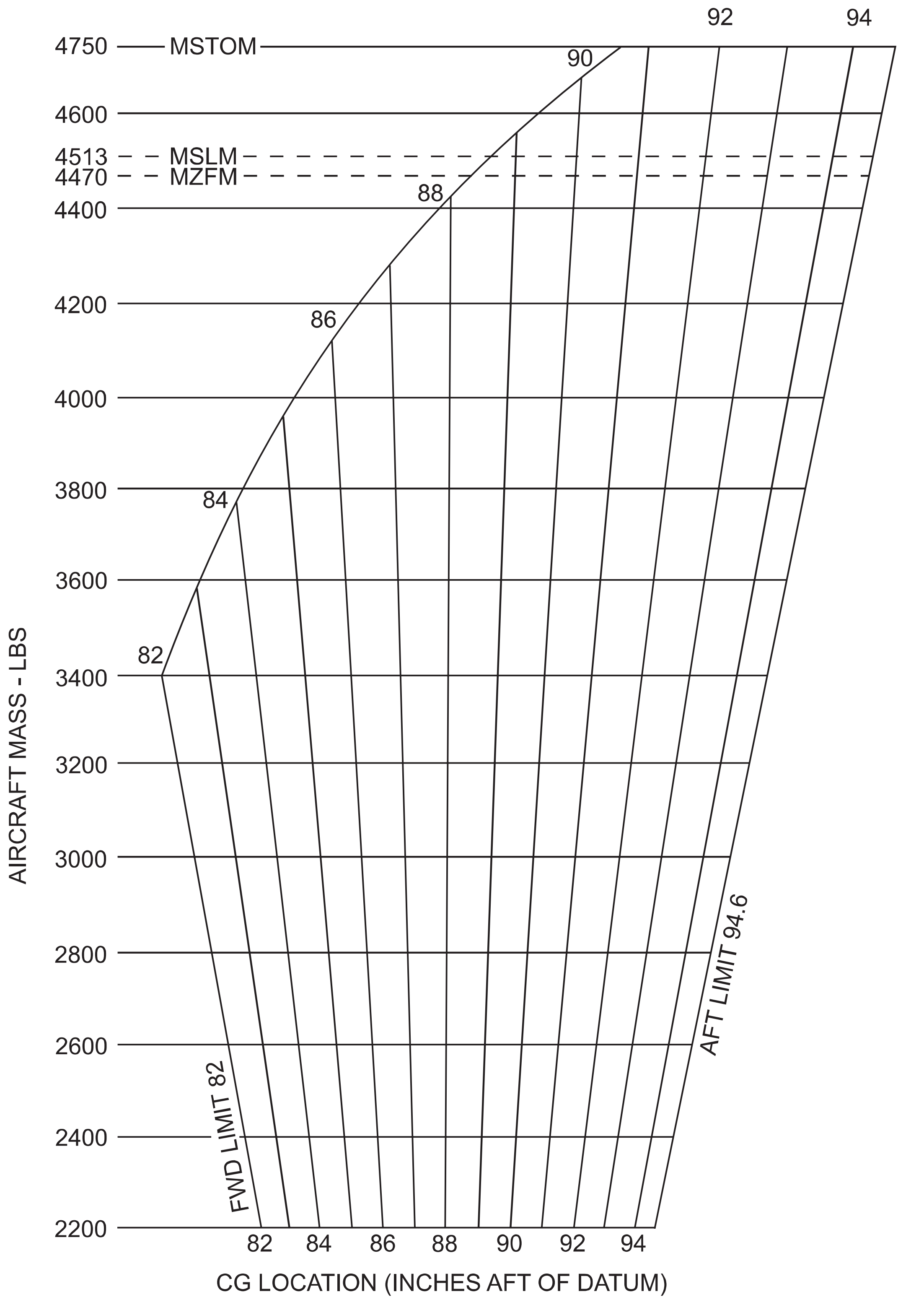


Figure 3.5 Blank Centre of Gravity Envelope

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5 Conversions

The following conversions, based on those in ICAO Annex 5, are satisfactory for use in JAR-FCL examinations in 030 subjects.

5.1 Mass Conversions

Pounds (lb) to Kilograms (kg)	lb × 0.454
Kilograms (kg) to Pounds (lb)	kg × 2.205

5.2 Volumes (Liquid)

Imperial Gallons to Litres (l)	Imp. Gal × 4.546
US Gallons to Litres (l)	US Gal × 3.785

5.3 Lengths

Feet (ft) to Metres (m)	Feet × 0.305

5.4 Distances

Nautical mile (NM) to Metres (m)	NM × 1852.0

Section 2 Single-Engined Piston Aeroplane (SEP1)

1 Aeroplane Details

The aeroplane is a monoplane with a single reciprocating engine and a constant speed propeller. It has a retractable undercarriage.

MTOM	3,650 lb
MLM	3,650 lb
Maximum fuel load	74 US gallons
Fuel Density	6 lb per US gallon (unless otherwise specified)

2 Fuel, Time and Distance to Climb

2.1 Calculation Method

a) Enter the graph at the ambient temperature of the aerodrome (or start of climb) and travel vertically to intersect the aerodrome (or start of climb) Pressure Altitude grid-line.

b) From this grid-line move horizontally right to intersect the aeroplane mass grid-line, interpolating if necessary.

c) From this point drop vertically to read the time taken to climb from the upper scale, fuel used on the climb from the middle scale and the air distance from the bottom scale.

d) Enter the graph at the ambient temperature at the top of climb and travel vertically to intersect the top of climb Pressure Altitude grid-line.

e) From this grid-line move horizontally right to intersect the aeroplane mass grid-line, interpolating if necessary.

f) From this point drop vertically and read the time taken to climb from the upper scale, fuel used on the climb from the middle scale and the air distance from the bottom scale.

g) Subtract the values determined at c) above from those determined at f) above to obtain the values of the time taken to climb, the fuel used to climb and the air distance travelled in the climb.

2.2 Example

Aerodrome Pressure Altitude	5,653 ft
Aerodrome Ambient Temperature	+15°C
Cruise Pressure Altitude	11,500 ft
Cruise Ambient Temperature	-5°C
Initial Climb Weight	3,650 lb

2.3 Solution

Graphical values at the aerodrome altitude = 6.5 min; 2.5 US gal; Dist. 12.5 NAM.
Graphical values at the top of climb altitude = 18.0 min; 6.0 US gal; Dist. 36.0 NAM.
Values for the climb =11.5 min; 3.5 US gal; 23.5 NAM.

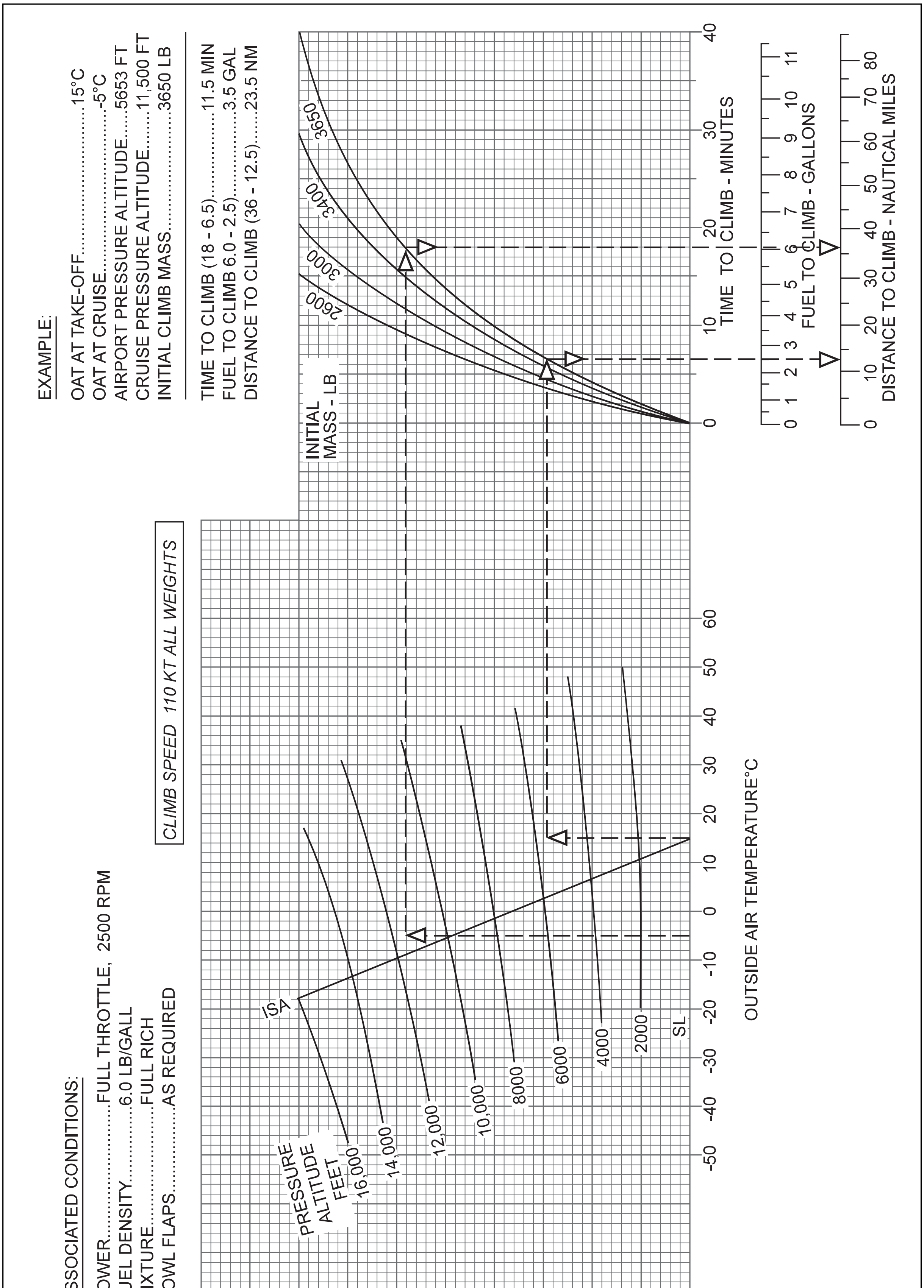

Figure 2.1 Time, Fuel and Distance to Climb

3 Recommended and Economy Cruise Power Settings

The following Tables cover cruises with 20°C lean mixture.

Table 2.2.1: 25.0 in. Hg (or full throttle); 2,500 RPM – recommended cruise power
Table 2.2.2: 25.0 in. Hg (or full throttle); 2,100 RPM – recommended cruise power
Table 2.2.3: 23.0 in. Hg (or full throttle); 2,300 RPM – recommended cruise power
Table 2.3.1: 21.0 in. Hg (or full throttle); 2,100 RPM – economy cruise power

3.1 Method of use

a) Select the correct table for the power setting.
b) Select the appropriate temperature deviation block(s).
c) Enter the block(s) at the appropriate cruising level.
d) If necessary, interpolate to extract the required data.

Table 2.2.1 **25.0 in. Hg (or full throttle) @ 2,500 rpm**
Off-peak EGT Cruise lean mixture @ cruise weight 3,400 lb

ISA Dev.	Press. Alt.	IOAT		Man. Press.	Fuel Flow		Airspeed	
°C	Feet	°C	°F	In. Hg	PPH	GPH	KIAS	KTAS
-20	0	-3	27	25.0	86.3	14.4	168	159
	2,000	-6	20	25.0	89.3	14.9	168	164
	4,000	-10	13	25.0	92.3	15.4	168	169
	6,000	-14	6	24.1	89.8	15.0	164	170
	8,000	-18	-1	22.3	82.6	13.8	157	168
	10,000	-22	-8	20.6	76.0	12.7	150	165
	12,000	-26	-15	19.1	70.2	11.7	143	162
	14,000	-30	-23	17.7	65.5	10.9	135	158
	16,000	-35	-30	16.3	60.8	10.1	126	152
0	0	17	63	25.0	82.9	13.8	163	160
	2,000	14	56	25.0	85.6	14.3	163	165
	4,000	10	50	25.0	88.5	14.8	163	170
	6,000	6	42	24.1	86.1	14.4	159	171
	8,000	2	35	22.3	79.3	13.2	152	169
	10,000	-2	28	20.6	73.3	12.2	145	166
	12,000	-6	21	19.1	67.8	11.3	137	162
	14,000	-10	13	17.7	63.5	10.6	129	157
	16,000	-15	6	16.3	59.1	9.9	120	150
+20	0	37	99	25.0	79.5	13.3	158	161
	2,000	34	92	25.0	82.1	13.7	158	166
	4,000	30	86	25.0	84.7	14.1	158	171
	6,000	26	79	24.1	82.5	13.8	154	172
	8,000	22	71	22.3	76.2	12.7	147	169
	10,000	18	64	20.6	70.5	11.8	140	165
	12,000	14	57	19.1	65.5	10.9	132	161
	14,000	10	49	17.7	61.5	10.3	123	155
	16,000	5	42	16.3	57.5	9.6	113	146

Figure 2.2 Recommended Cruise Power Settings

NOTE 1: Full-throttle manifold pressure settings are approximate.

NOTE 2: Shaded areas represent operation with full throttle.

NOTE 3: Fuel flows are to be used for flight planning. Lean using the EGT.

Table 2.2.2 **25.0 in. Hg (or full throttle) @ 2,100 rpm**

Off-peak EGT Cruise lean mixture @ cruise weight 3,400 lb

ISA Dev.	Press. Alt.	IOAT		Man. Press.	Fuel Flow		Airspeed	
°C	Feet	°C	°F	In. Hg	PPH	GPH	KIAS	KTAS
-20	0	-3	26	25.0	63.8	10.6	148	140
	2,000	-7	19	25.0	66.4	11.1	149	145
	4,000	-11	12	25.0	68.9	11.5	149	150
	6,000	-15	5	24.3	68.3	11.4	147	152
	8,000	-19	-2	22.5	63.9	10.7	139	148
	10,000	-23	-9	20.8	60.1	10.0	132	144
	12,000	-27	-17	19.3	56.7	9.5	123	139
	14,000	-31	-24	17.9	54.5	9.1	113	132
	16,000	-35	-32	16.5	52.2	8.7	95	114
0	0	17	62	25.0	61.9	10.3	143	140
	2,000	13	55	25.0	64.2	10.7	143	145
	4,000	9	48	25.0	66.6	11.1	144	150
	6,000	5	41	24.3	66.1	11.0	141	152
	8,000	1	34	22.5	61.9	10.3	134	148
	10,000	-3	27	20.8	58.5	9.8	126	143
	12,000	-7	19	19.3	55.6	9.3	116	136
	14,000	-11	12	17.9	53.5	8.9	103	125
	16,000	-	-	-	-	-	-	-
+20	0	37	98	25.0	60.1	10.0	138	140
	2,000	33	91	25.0	62.1	10.4	138	145
	4,000	29	84	25.0	64.4	10.7	139	150
	6,000	25	77	24.3	63.9	10.7	136	151
	8,000	21	70	22.5	60.2	10.0	128	147
	10,000	17	63	20.8	56.8	9.5	119	141
	12,000	13	55	19.3	54.5	9.1	108	131
	14,000	-	-	-	-	-	-	-
	16,000	-	-	-	-	-	-	-

Figure 2.2 Recommended Cruise Power Settings (continued)

NOTE 1: Full-throttle manifold pressure settings are approximate.

NOTE 2: Shaded areas represent operation with full throttle.

NOTE 3: Fuel flows are to be used for flight planning. Lean using the EGT.

Table 2.2.3 **23.0 in. Hg (or full throttle) @ 2,300 rpm**

Off-peak EGT Cruise lean mixture @ cruise weight 3,400 lb

ISA Dev.	Press. Alt.	IOAT		Man. Press.	Fuel Flow		Airspeed	
°C	Feet	°C	°F	In. Hg	PPH	GPH	KIAS	KTAS
-20	0	-3	26	23.0	67.6	11.3	152	144
	2,000	-7	20	23.0	69.7	11.6	152	149
	4,000	-11	13	23.0	72.1	12.0	153	154
	6,000	-15	6	23.0	74.4	12.4	153	158
	8,000	-18	-1	22.4	73.8	12.3	150	160
	10,000	-23	-9	20.7	68.4	11.4	143	157
	12,000	-27	-16	19.2	63.8	10.6	135	153
	14,000	-31	-23	17.8	60.0	10.0	127	148
	16,000	-35	-31	16.4	56.3	9.4	117	141
0	0	17	62	23.0	65.4	10.9	147	145
	2,000	13	56	23.0	67.4	11.2	147	149
	4,000	9	49	23.0	69.4	11.6	148	154
	6,000	5	42	23.0	71.7	12.0	148	159
	8,000	2	35	22.4	71.1	11.9	145	160
	10,000	-3	27	20.7	66.2	11.0	137	157
	12,000	-7	20	19.2	61.8	10.3	129	152
	14,000	-11	13	17.8	58.5	9.8	120	146
	16,000	-15	5	16.4	55.3	9.2	109	137
+20	0	37	98	23.0	63.2	10.5	142	145
	2,000	33	92	23.0	65.1	10.9	143	149
	4,000	29	85	23.0	67.1	11.2	143	154
	6,000	25	78	23.0	69.0	11.5	142	158
	8,000	22	71	22.4	68.5	11.4	140	160
	10,000	17	63	20.7	64.0	10.7	132	156
	12,000	13	56	19.2	60.0	10.0	123	151
	14,000	9	48	17.8	57.1	9.5	113	142
	16,000	-	-	-	-	-	-	-

Figure 2.2 Recommended Cruise Power Settings (continued)

NOTE 1: Full-throttle manifold pressure settings are approximate.

NOTE 2: Shaded areas represent operation with full throttle.

NOTE 3: Fuel flows are to be used for flight planning. Lean using the EGT.

Table 2.3.1 **21.0 in. Hg (or full throttle) @ 2,100 rpm**

Off-peak EGT Cruise lean mixture @ cruise weight 3,400 lb

ISA Dev.	Press. Alt.	IOAT		Man. Press.	Fuel Flow		Airspeed	
°C	Feet	°C	°F	IN. HG	PPH	GPH	KIAS	KTAS
-20	0	-4	25	21.0	52.7	8.8	126	120
	2,000	-8	18	21.0	54.0	9.0	128	125
	4,000	-11	12	21.0	55.4	9.2	130	130
	6,000	-15	5	21.0	56.9	9.5	131	136
	8,000	-19	-2	21.0	58.9	9.8	132	141
	10,000	-23	-9	20.8	60.1	10.0	132	144
	12,000	-27	-17	19.3	56.7	9.5	123	139
	14,000	-31	-24	17.9	54.5	9.1	113	132
	16,000	-35	-32	16.5	52.2	8.7	95	114
0	0	16	61	21.0	51.8	8.6	120	118
	2,000	12	54	21.0	53.1	8.9	123	124
	4,000	9	48	21.0	54.4	9.1	124	129
	6,000	5	41	21.0	55.7	9.3	125	134
	8,000	1	34	21.0	57.3	9.6	126	140
	10,000	-3	27	20.8	58.5	9.8	126	143
	12,000	-7	19	19.3	55.6	9.3	116	137
	14,000	-11	12	17.9	53.5	8.9	103	125
	16,000	-	-	-	-	-	-	-
+20	0	36	97	21.0	50.8	8.5	114	115
	2,000	32	90	21.0	52.1	8.7	116	121
	4,000	29	83	21.0	53.4	8.9	118	127
	6,000	25	77	21.0	54.7	9.1	119	132
	8,000	21	70	21.0	55.9	9.3	120	137
	10,000	17	63	20.8	56.8	9.5	119	141
	12,000	13	55	19.3	54.5	9.1	108	131
	14,000	-	-	-	-	-	-	-
	16,000	-	-	-	-	-	-	-

Figure 2.3 Economy Cruise Power Settings

NOTE 1: Full-throttle manifold pressure settings are approximate.

NOTE 2: Shaded areas represent operation with full throttle.

NOTE 3: Fuel flows are to be used for flight planning. Lean using the EGT.

4 Range Profile

The graph at Figure 2.4 provides a simple and rapid means of determining the still-air range (nautical miles) for the sample aeroplane. An example of the use of the graph is shown.

NOTE: The figures make allowance for the taxi, run-up and 45 minutes reserve fuel.

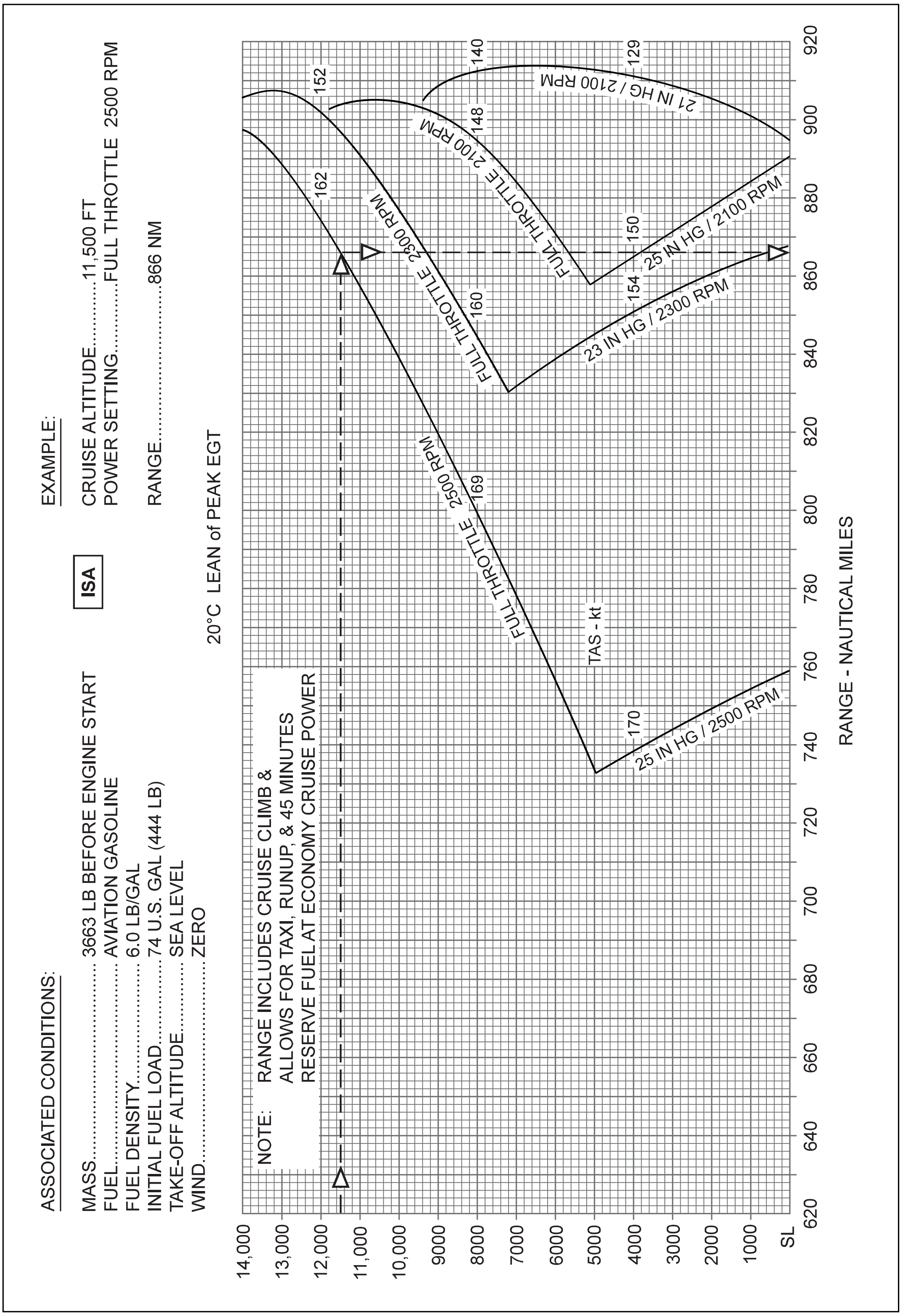

Figure 2.4 Range

5 Endurance Profile

The graph at Figure 2.5 provides a rapid method for determination of endurance for the sample aeroplane. An example is shown on the graph.

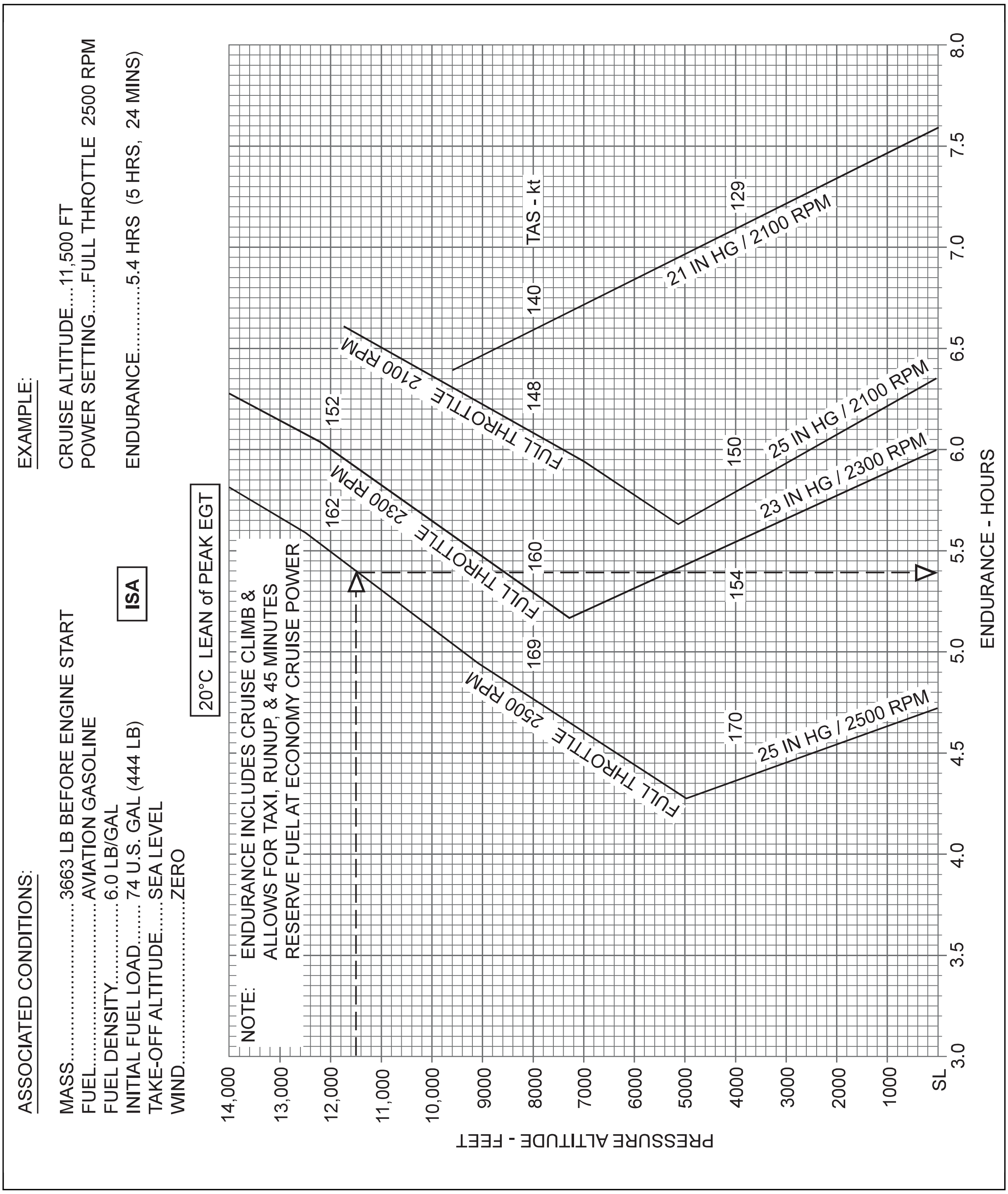

Figure 2.5 Endurance

Section 3 Multi-Engined Piston Aeroplane (MEP1)

1 Aeroplane Details

The aeroplane is a monoplane with twin reciprocating engines and twin counter-rotating, constant speed propellers. It has a retractable undercarriage.

MTOM	4,750 lb
MZFM	4,470 lb
MLM	4,513 lb
Maximum fuel load	123 US gallons
Fuel Density	6 lb per US gallon (unless otherwise specified)

2 Fuel, Time and Distance to Climb

2.1 Calculation Method

a) Enter the graph (Figure 3.1) at the ambient temperature of the aerodrome (or start of climb) and travel vertically to intersect the aerodrome (or start of climb) Pressure Altitude grid-line.

b) From this grid-line move horizontally right to intersect the fuel, time and distance grid-lines in turn.

c) From each intersection drop vertically to read the appropriate value from the graph.

d) Enter the graph at the ambient temperature at the top of climb and travel vertically to intersect the top of climb Pressure Altitude grid-line.

e) From this grid-line move horizontally right to intersect the fuel, time and distance grid-lines in turn.

f) From each intersection drop vertically to read the appropriate value from the graph.

g) Subtract the values determined at c) above from those determined at f) above to obtain the values of the fuel used to climb, the time taken to climb, and the air distance travelled in the climb.

2.2 Example

Aerodrome Pressure Altitude	2,000 ft
Aerodrome Ambient Temperature	+21°C
Cruise Pressure Altitude	16,500 ft
Cruise Ambient Temperature	-13°C

2.3 Solution

Graphical values at the aerodrome altitude = 3.0 min; 2.0 US gal; Dist. 5.0 NAM.

Graphical values at the top of climb altitude = 27.0 min; 15.0 US gal; Dist. 50.0 NAM.

Values for the climb = 24.0 min; 13.0 US gal; 45.0 NAM.

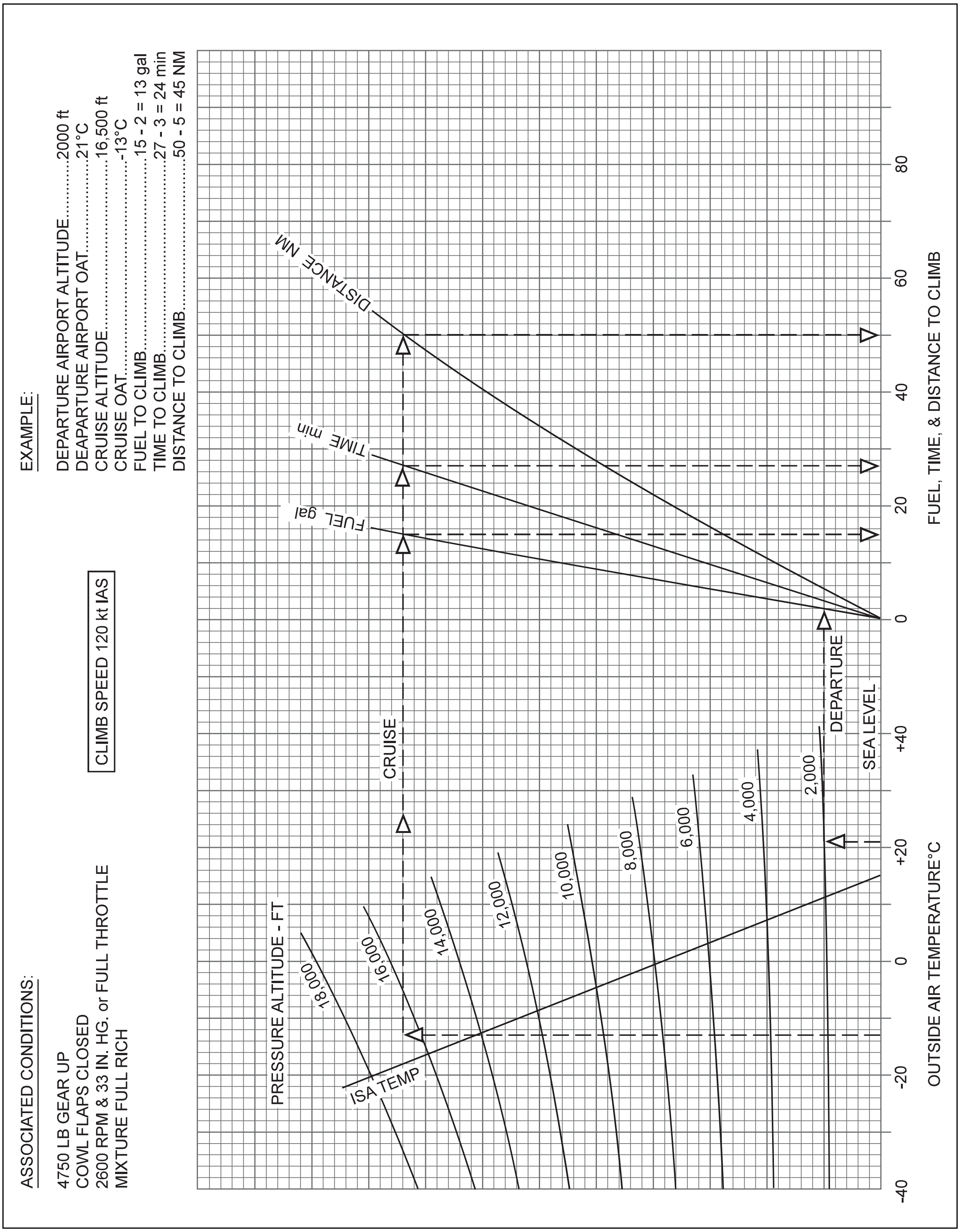

Figure 3.1 Climb

3 Range at Standard Temperatures

3.1 Calculation Method

a) Enter Figure 3.2 at the left vertical axis with the cruise Pressure Altitude.

b) Travel horizontally right to intersect the grid-line appropriate to the power setting (with or without reserve).

c) Drop vertically to read the still-air range.

d) To determine the wind effective range, multiply the still-air range by the groundspeed and divide by the TAS.

e) The TAS can be determined from Figure 3.4 using the cruise Pressure Altitude, standard temperature and the appropriate power setting.

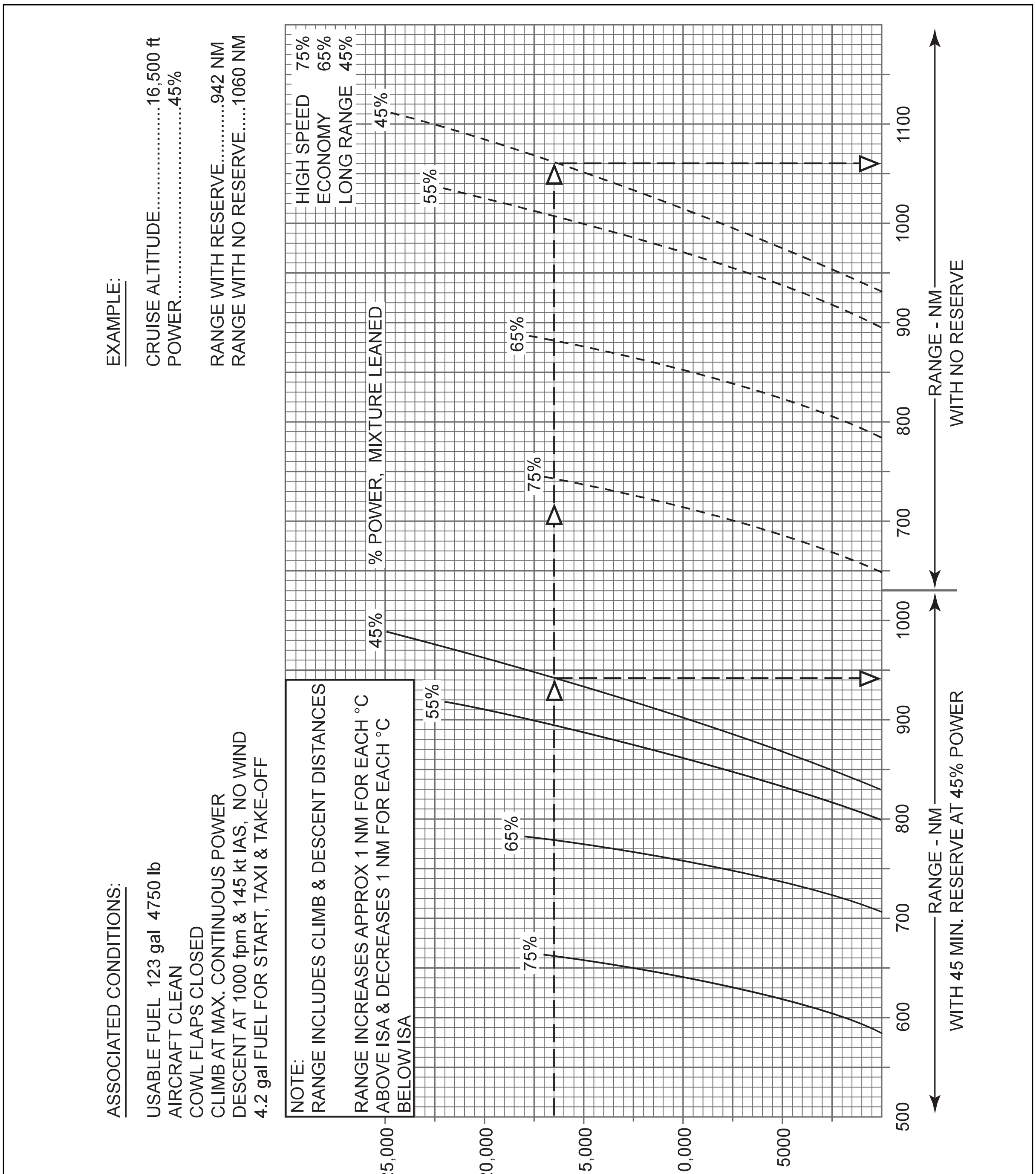

Figure 3.2 Range

4 Cruise Power Setting and Fuel Flow

4.1 Calculation Method

4.1.1 Enter the Power Setting table (Figure 3.3) at the cruise Pressure Altitude and travel horizontally right to the block appropriate to the power setting. At the top of the block read the fuel flow in US gallons per hour. In the same block select the column appropriate to the RPM and at the cruise Pressure Altitude read the manifold pressure.

4.1.2 These tables are for ISA deviation 0°C. To maintain constant power at temperature deviations other than 0° the manifold pressure must be corrected by adding 1% for each 6°C above the standard temperature or by subtracting 1% for each 6°C below the standard temperature.

The Cruise Manifold Pressure must not exceed 34 inches.

POWER		75%		65%			55%						45%					
FUEL FLOW		29.0 GPH		23.3 GPH			18.7 GPH						16.0 GPH					
RPM		2,500	2,600	2,400	2,500	2,600	2,100	2,200	2,300	2,400	2,500	2,600	2,100	2,200	2,300	2,400	2,500	2,600
PRESS ALT (ft)	ISA 0°C	MANIFOLD ABSOLUTE PRESSURE (Hg in) (MAP)																
0	15	34.0	33.0	33.8	32.0	31.0	31.2	30.3	29.4	28.2	27.2	26.3	27.1	26.4	25.5	24.3	23.3	22.5
2,000	11	33.8	32.7	33.2	31.7	30.7	30.5	29.7	28.8	27.8	26.8	26.0	26.4	25.8	24.6	23.7	22.8	22.1
4,000	7	33.6	32.4	32.8	31.5	30.5	30.0	29.2	28.3	27.4	26.4	25.6	25.8	25.0	24.0	23.2	22.3	21.8
6,000	3	33.4	32.2	32.5	31.2	30.3	29.7	28.8	28.0	27.0	26.2	25.3	25.3	24.5	23.5	22.8	21.9	21.5
8,000	-1	33.1	32.0	32.3	31.0	30.1	29.4	28.4	27.7	26.8	25.7	25.0	24.8	24.0	23.0	22.4	21.6	21.2
10,000	-5	33.0	31.9	32.0	30.9	30.0	-	28.3	27.5	26.5	25.5	24.7	24.4	23.7	22.8	22.0	21.4	21.0
12,000	-9	32.5	31.8	31.8	30.7	29.8	-	28.3	27.2	26.3	25.3	24.6	24.0	23.3	22.5	21.7	21.2	20.9
14,000	-13	-	31.7	-	30.5	29.7	-	-	27.1	26.1	25.2	24.4	-	23.0	22.3	21.4	21.1	20.8
16,000	-17	-	31.6	-	30.4	29.5	-	-	-	25.9	25.0	24.3	-	-	22.0	21.3	21.0	20.6
18,000	-21	-	-	-	-	29.4	-	-	-	-	25.0	24.2	-	-	-	21.2	20.9	20.5
20,000	-25	-	-	-	-	29.3	-	-	-	-	-	24.2	-	-	-	21.2	20.8	20.4
22,000	-28	-	-	-	-	-	-	-	-	-	-	24.1	-	-	-	-	-	20.4
MAX EGT		1,525°F		1,650°F														
24,000	-33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.4
25,000	-34	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20.4

Figure 3.3 Power Setting Table

5 True Airspeed

The graph at Figure 3.4 should be used to determine the true airspeed for the various combinations of ambient temperature, Pressure Altitude and power settings in the cruise configuration. The example on the graph illustrates the method of use.

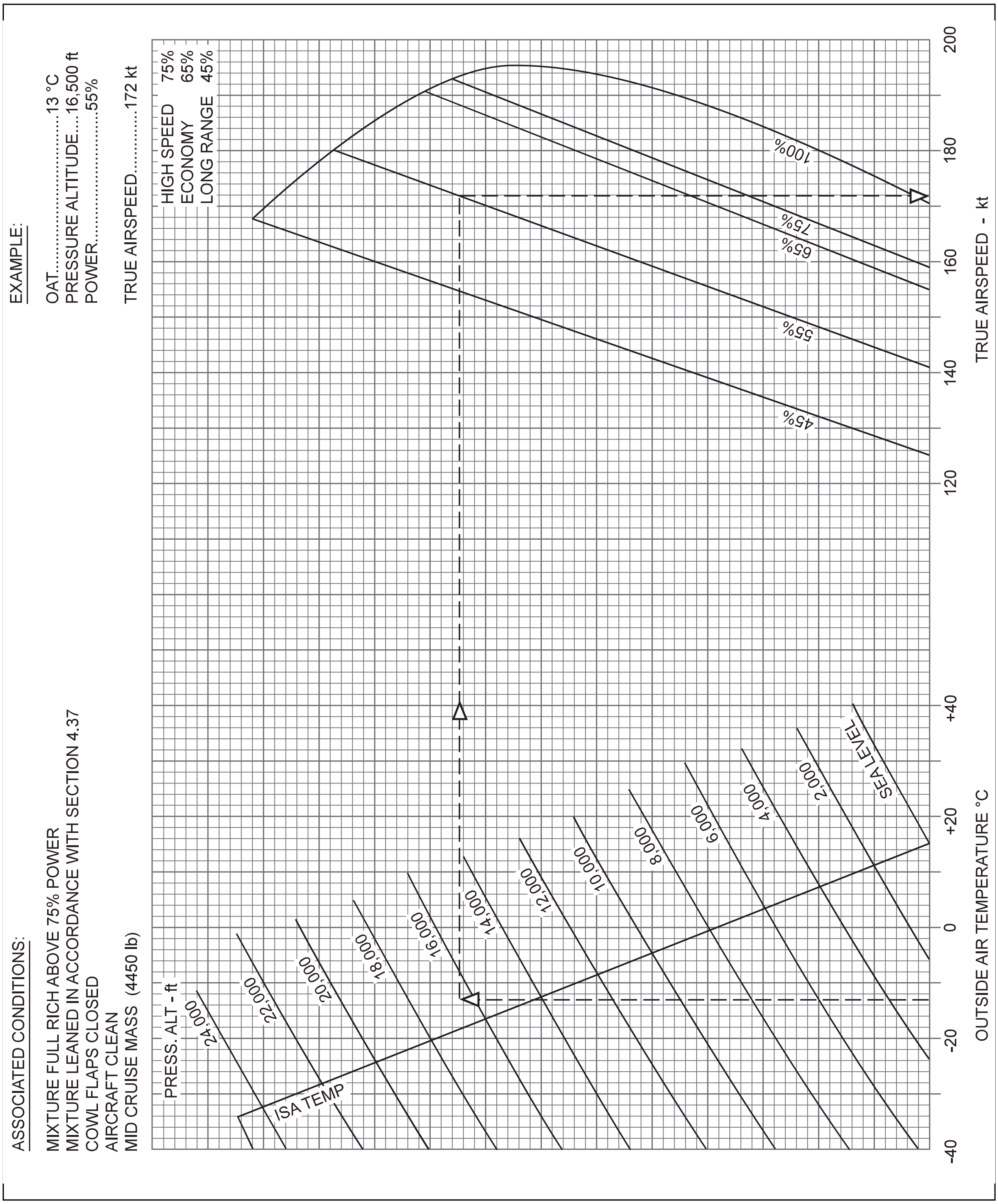

Figure 3.4 Speed v Power

6 Endurance

6.1 Method of Use

a) Enter the left vertical axis of Figure 3.5 at the cruise Pressure Altitude.

b) Move horizontally right to the appropriate power setting grid line – either the one with 45 minutes reserve (the Safe Endurance) or the one with no reserve (the Maximum Endurance).

c) From the intersection at b) travel vertically down to read the safe endurance in hours (or maximum endurance).

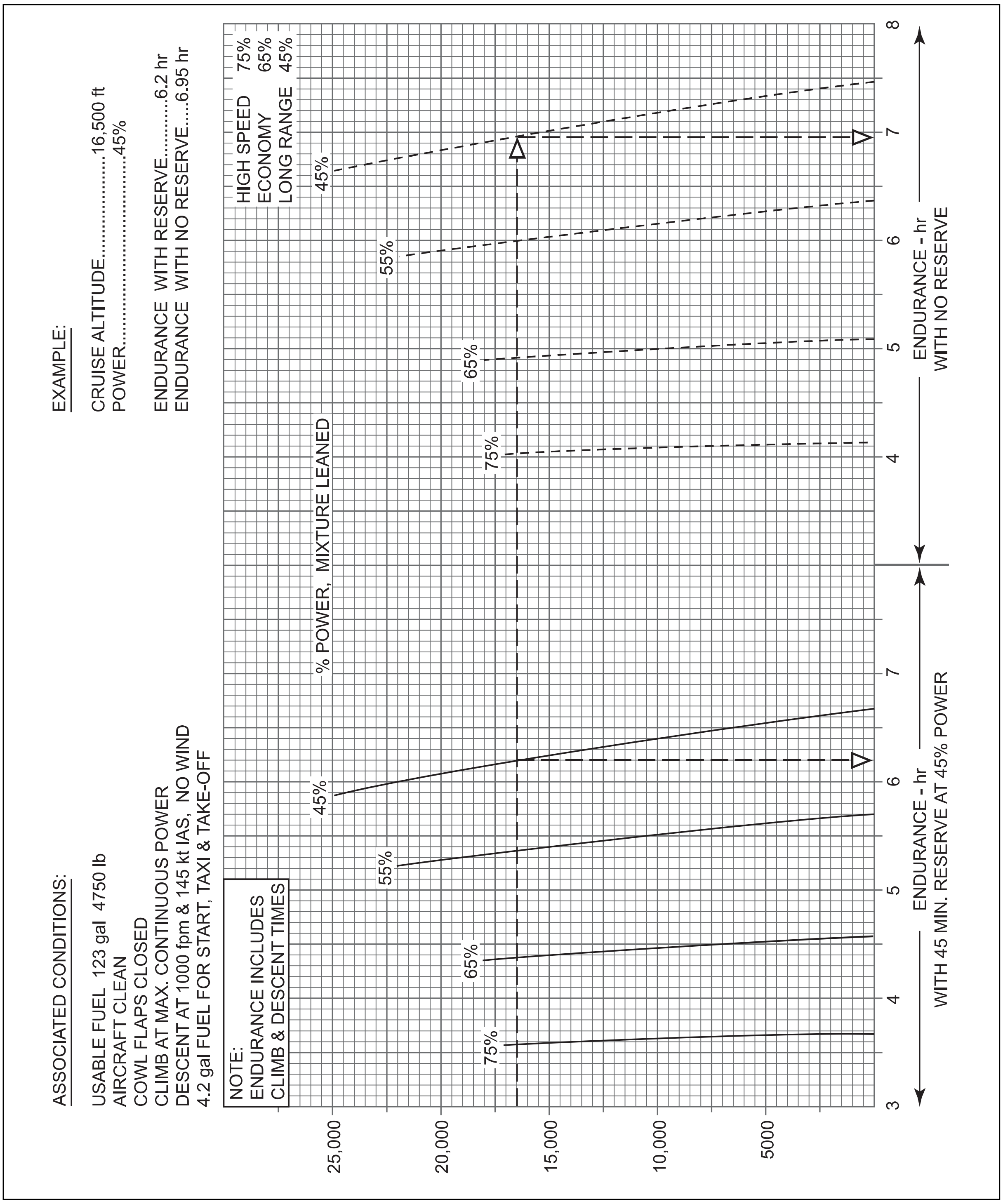

Figure 3.5 Endurance

7 Descent

7.1 Calculation Method

a) Enter Figure 3.6 with OAT at cruise altitude and move vertically to intersect the cruise Pressure Altitude.

b) From this intersection travel horizontally right to intersect the grid-lines in turn, then drop vertically to read the fuel used, time taken and air distance travelled.

c) The procedure at b) above must be done twice, once for the aerodrome (or end of descent) data and a second time for the cruising altitude data.

d) Subtract the values for the aerodrome (or end of descent) from the cruising altitude values to determine the values for the descent.

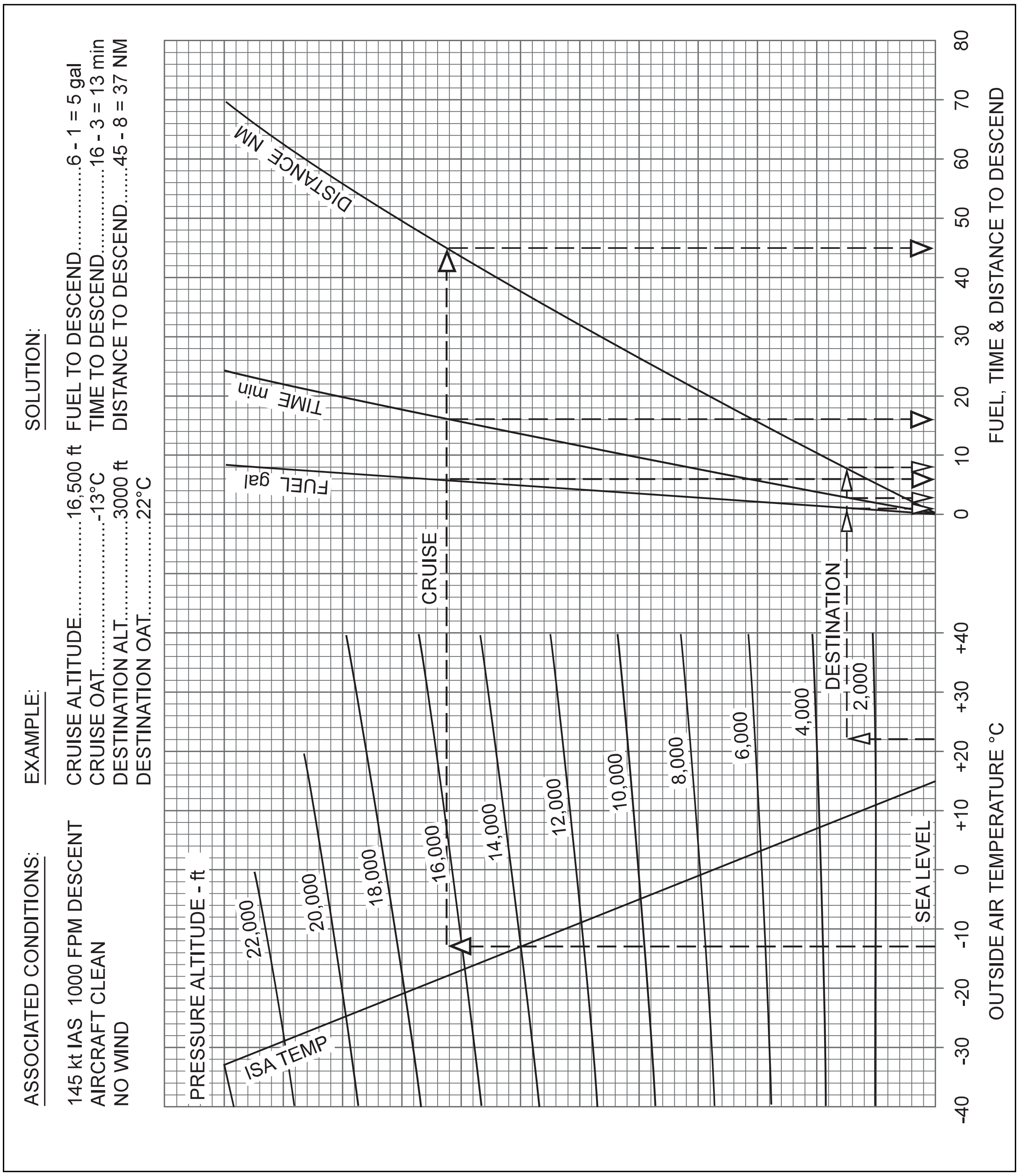

Figure 3.6 Fuel, Time and Distance to Descend

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Section 2 Data for Single-Engine Piston Aeroplane (SEP1)

1 General Considerations

1.1 Performance Classification

The specimen aeroplane is a low wing monoplane with retractable undercarriage. It is powered by a single reciprocating engine and a constant speed propeller.

The aeroplane, which is not certificated under CS/FAR 25, is a land-plane classified in Performance Class B.

1.2 General Requirements

An operator shall not operate a single-engine aeroplane:

a) At night.

b) In instrument meteorological conditions except under special visual flight rules.

c) Unless surfaces are available which permit a safe forced landing to be executed.

d) Above a cloud layer that extends below the relevant minimum safe altitude.

1.3 Aeroplane Limitations

Structural Limitations

Maximum Take-Off Mass	3650 lb
Maximum Landing Mass	3650 lb
Maximum Runway Cross Wind	17 kt

2 Take-Off

2.1 Requirements

The only take-off requirement for a single engined aeroplane is for the Field Length as detailed in paragraph 2.1.1 below. As explained in paragraph 3, there is no take-off climb requirement.

2.1.1 Field Length Requirements

a) When no stopway or clearway is available the take-off distance when multiplied by 1.25 must not exceed TORA.

b) When a stopway and/or clearway is available the take-off distance must:

i) not exceed TORA

ii) when multiplied by 1.3, not exceed ASDA

iii) when multiplied by 1.15, not exceed TODA

c) If the runway surface is other than dry and paved the following factors must be used when determining the take-off distance in a) or b) above:

Surface Type	Condition	Factor
Grass (on firm soil)	Dry	x 1.2
up to 20 cm Long	Wet	x 1.3
Paved	Wet	x 1.0

d) Take-off distance should be increased by 5% for each 1% upslope. No factorisation is permitted for downslope.

NOTE: The same surface and slope correction factors should be used when calculating TOR or ASD.

2.2 Use of Take-Off Graphs

There are two take-off distance graphs. One with flaps up (Figure 2.1) and the other with flaps approach (Figure 2.2). These graphs are used in exactly the same manner.

2.2.1 Distance Calculation

To determine the take-off distance:

a) Select the graph appropriate to the flap setting.

b) Enter at the OAT. Move vertically up to the aerodrome pressure altitude.

c) From this point, travel horizontally right to the mass reference line. Parallel the grid lines to the take-off mass input.

d) Continue horizontally right to the wind component reference line. Parallel the grid lines to the wind component input.

e) Proceed horizontally right to the obstacle reference line. Continue horizontally right to read ground roll distance or proceed parallel to the grid lines to read total distance to 50ft obstacle (TOD).

f) Factorise for surface and slope.

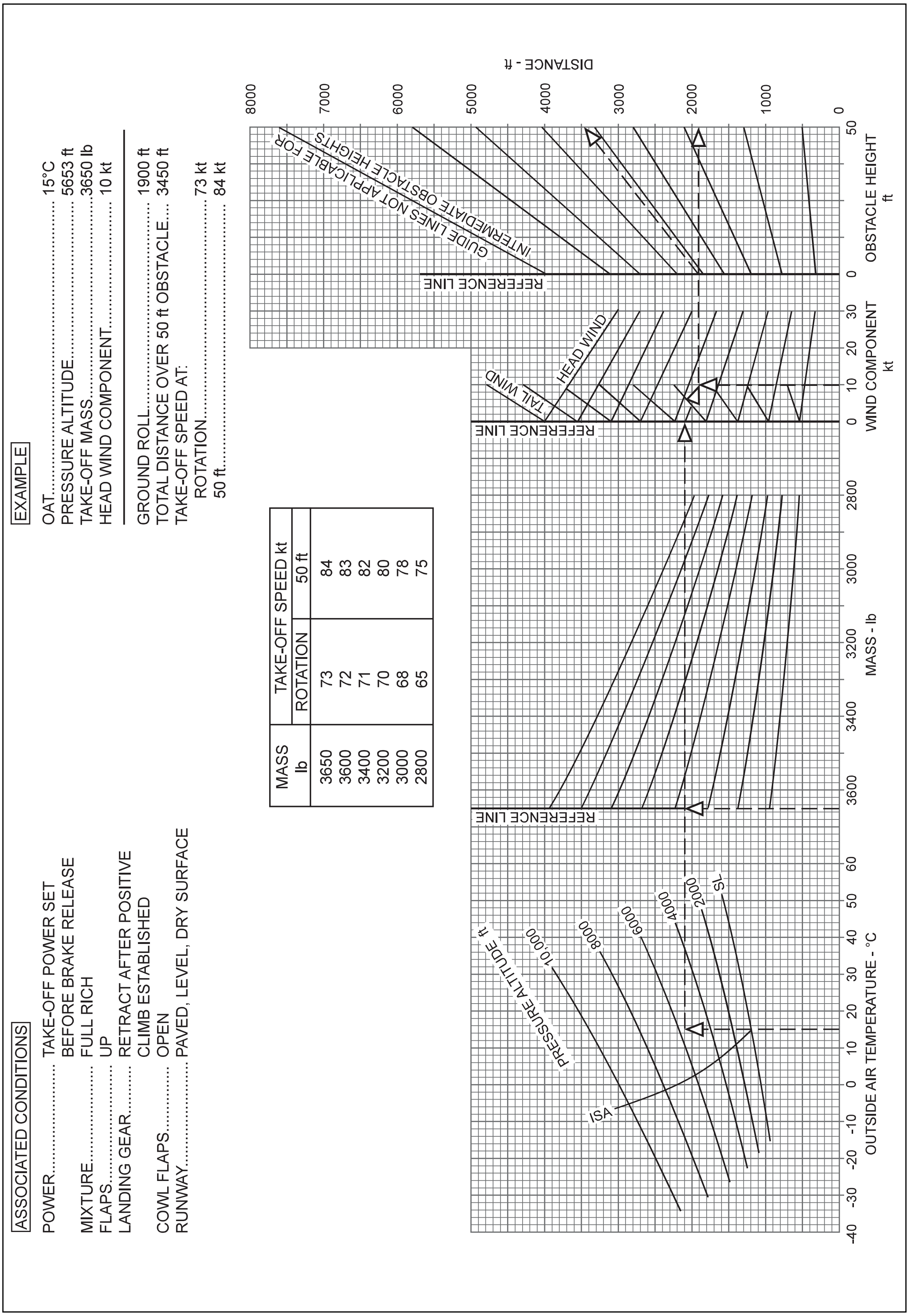
Example: Flaps Up

Aerodrome Pressure Altitude	5653 ft
Ambient Temperature	+15°C
Take-Off Mass	3650 lb
Wind Component	10 kt Head
Runway Slope	1.5% Uphill
Runway Surface	Grass
Runway Condition	Wet

Calculate: Take-Off Distance

Solution:

Graphical Distance	3450 ft
Surface Factor	x 1.3
Slope Factor	x 1.075
Take-Off Distance	4821 ft



MASS lb	TAKE-OFF SPEED kt ROTATION	50 ft
3650	73	84
3600	72	83
3400	71	82
3200	70	80
3000	68	78
2800	65	75

Figure 2.1 Take-Off Distance Flaps Up

2.2.2 Mass Calculation

To calculate the field length limited take-off mass it is necessary to apply the requirements of JAR-OPS. Only the take-off distance graph is used but the right vertical axis is entered with shortest available de-factored distance. The factors to be considered are those of slope, surface, condition and regulation.

a) Enter at the ambient temperature. Move vertically to the aerodrome pressure altitude.

b) From this point, travel horizontally right to the mass reference line. Mark this position with a pencil.

c) Enter the right vertical axis with the shortest available de-factored distance at the 50ft height. Parallel the grid lines down to the reference line.

d) Now travel horizontally left to the appropriate wind component input. Parallel the grid lines to the wind component reference line.

e) From this point, draw a horizontal line left through the mass grid.

f) From the position marked in b), above, parallel the grid lines to intersect the horizontal line from e), above.

g) At the intersection, drop vertically to read the field length limited TOW.

Example: Flaps Approach

Aerodrome Pressure Altitude	5653 ft
Ambient Temperature	+15°C
Wind Component	10 kt Head
Runway Slope	2% Uphill
Runway Surface	Grass
Runway Condition	Dry

TORA 4250 ft; ASDA 4470 ft; TODA 4600 ft

Calculate the Field Length Limited TOW.

	TORA	**ASDA**	**TODA**
Given Distances	4250 ft	4470 ft	4600 ft
Slope Factor	1.1	1.1	1.1
Surface/Condition Factor	1.2	1.2	1.2
Regulation Factor	1.0	1.3	1.15
De-factored Distance	3220 ft	2605 ft	3030 ft

Field Length Limited TOW 3530 lb Using 2605 ft

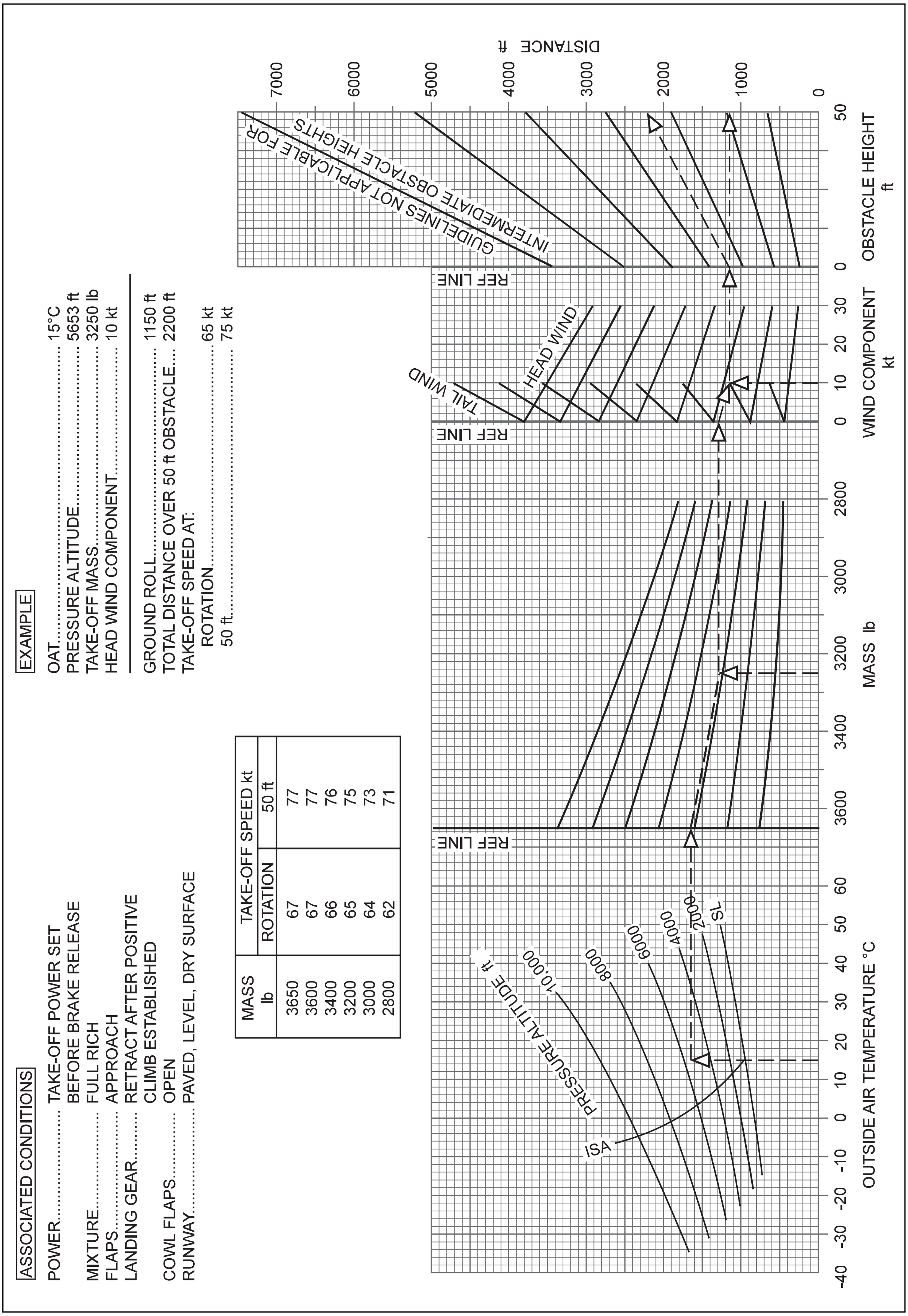


Figure 2.2 Take-Off Distance Flaps Approach

3 Take-Off Climb

3.1 Requirements

There are no obstacle clearance limits or minimum acceptable climb gradient required by JAR-OPS 1.

3.2 Use of Climb Graph

3.2.1 Climb Gradient and Rate of Climb.

To determine the climb gradient and rate of climb:

a) Use the navigation computer to calculate the TAS.
b) Enter the graph at the ambient temperature. Move vertically up to the pressure altitude.
c) From this point, travel horizontally right to the mass reference line. Parallel the grid lines to the appropriate mass input.
d) Now continue horizontally right to the first vertical axis to read the rate of climb. Continue horizontally to the TAS reference line.
e) Parallel the grid lines to intersect the TAS input then travel horizontally right to the right vertical axis to read the climb gradient.

Example:

Pressure Altitude	11500 ft
Ambient Temperature	-5°C
Weight	3600 lb

Solution:

Graphical ROC	515 fpm
TAS	120 kt
Climb Gradient	4.2%

3.2.2 Maximum Weight

To determine the maximum weight for a given gradient:

a) Enter the graph at the ambient temperature. Move vertically up to the Pressure Altitude.
b) From this point, travel horizontally right to the weight reference line and mark with a pencil.
c) Calculate the TAS using the Navigation Computer.
d) Enter the right vertical axis at the appropriate gradient and travel horizontally left to intercept the TAS calculated in c). From this point follow the grid lines to reach the reference line and draw a horizontal line through the weight grid.
e) From the pencil mark in b), above, parallel the grid lines to intersect the horizontal line drawn in d) above. Drop vertically to read the Climb-Limited Take-off weight.

Example:

Aerodrome Pressure Altitude	11000 ft
Ambient Temperature	+25°C
Gradient	4.2%

Solution:

TAS	125 kt
Maximum Weight	3360 lb

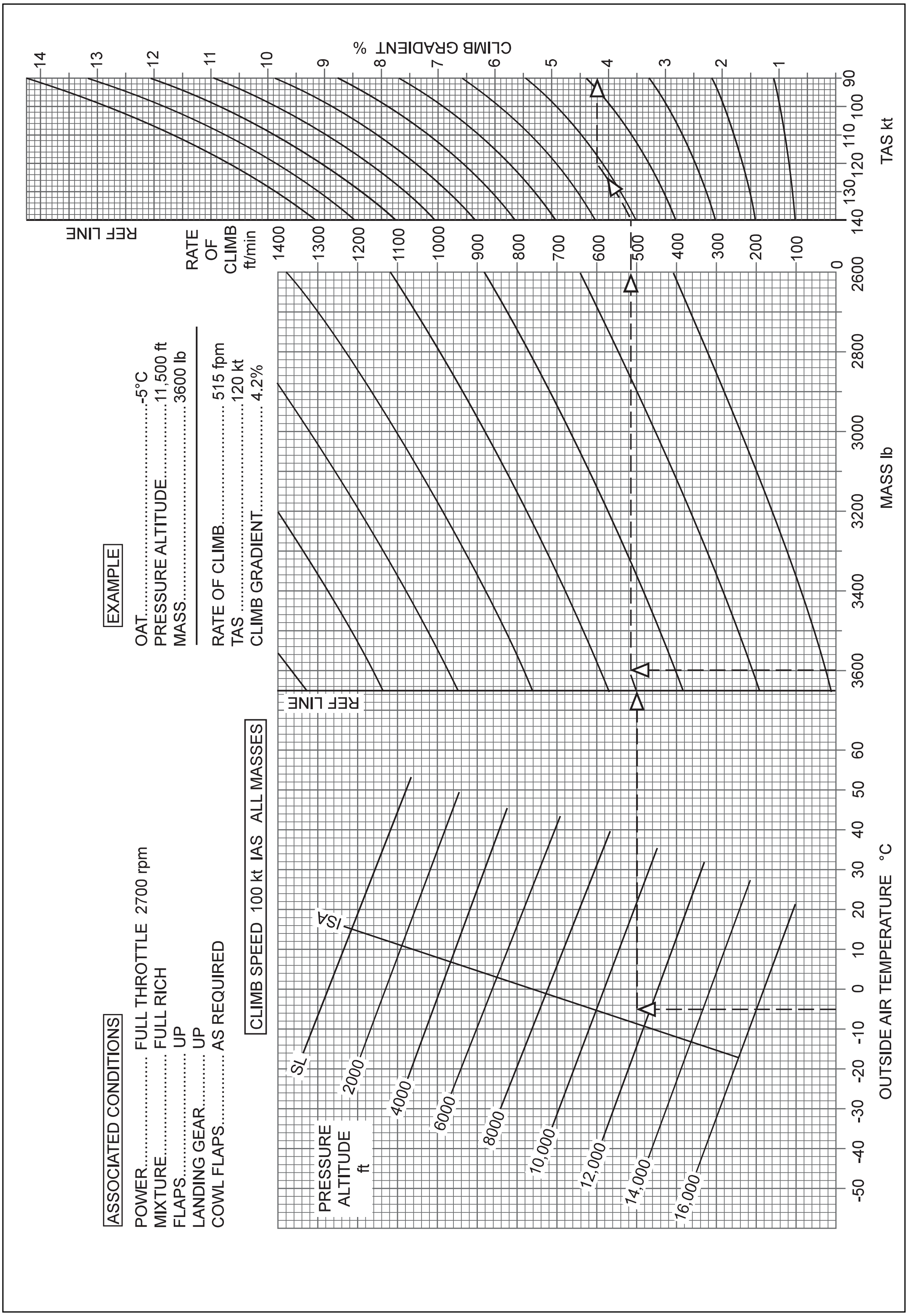


Figure 2.3 Climb

3.2.3 Distance to Reach given height.

To calculate the ground distance travelled in order to attain a given height above reference zero:

a) Convert the IAS 100 kt to a TAS, assume no position error.

b) Apply the wind component to the TAS to obtain the ground speed.

c) Determine the climb gradient from the graph.

d) Calculate the still air distance using the formula:

$$\text{Still Air Distance (ft)} = \frac{\text{Height Difference (ft)}}{\text{Gradient}} \times 100$$

e) Calculate ground distance using the formula:

$$\text{Ground Distance} = \text{Still Air Distance} \times \frac{\text{Groundspeed}}{\text{TAS}}$$

Example:

Aerodrome Pressure Altitude	4000 ft
Ambient Temperature	+30°C
Wind Component	30 kt tail
Take-Off Weight	3200 lb

Calculate the ground distance to reach 950 ft above reference zero from the end of TODR.

Solution:

100 kt IAS	= 110 kt TAS
Groundspeed	= 140 kt
Graph Gradient	= 10.0%
Still Air Distance	$= \frac{900}{10.0} \times 100 = 9000$ ft
Ground Distance	$= 9000 \times \frac{140}{110} = 11455$ ft = 1.88 NM.

4 En-Route

4.1 Requirements

The aeroplane may not be assumed to be flying above the altitude at which a rate of climb of 300 ft/min is attained.

The net gradient of descent, in the event of engine failure, shall be the gross gradient of descent increased by a gradient of 0.5%

5 Landing

5.1 Requirements

Field Length Requirements

a) The landing distance, from a screen height of 50 ft, must not exceed 70 % of the landing distance available, i.e. a factor of 1.43.

b) If the landing surface is grass up to 20 cm long on firm soil, the landing distance should be multiplied by a factor of 1.15.

c) If the METAR or TAF or combination of both indicate that the runway may be wet at the estimated time of arrival, the landing distance should be multiplied by a factor of 1.15.

d) The landing distance should be increased by 5% for each 1% downslope. No allowance is permitted for upslope.

e) The despatch rules for scheduled (planned) landing calculations are in JAR - OPS 1.550 (c).

5.2 Use of the Landing Field Length Graph

Distance Calculations

a) Enter at the ambient temperature. Move vertically to the aerodrome pressure altitude.

b) From this point, move horizontally right to the landing mass reference line. Parallel the grid lines to the appropriate landing mass input.

c) Continue from this intersection to the wind component reference line. Parallel the grid line to the appropriate wind component input.

d) Travel horizontally right to the ground roll reference line. Either continue horizontally to the right vertical axis to read the ground roll distance or parallel the grid lines to the right vertical axis to read the graphical distance.

e) Apply the surface and slope factors to the graphical distance to obtain the landing distance. Apply the regulatory factor to the landing distance to obtain the landing distance required.

Example: Normal Landing

Aerodrome Pressure Altitude	3965 ft
Ambient Temperature	+25°C
Landing Mass	3479 lb
Wind Component	10 kt Head
Runway Slope	1% down
Runway Surface	Grass
Runway Condition	Wet

Calculate Landing Distance Required

Solution:

Graphical Distance	1500 ft
Slope Correction Factor	x 1.05
Surface Correction Factor	x 1.15
Condition Correction Factor	x 1.15
Regulatory Factor	x 1.43
Landing Distance Required =	2979 ft

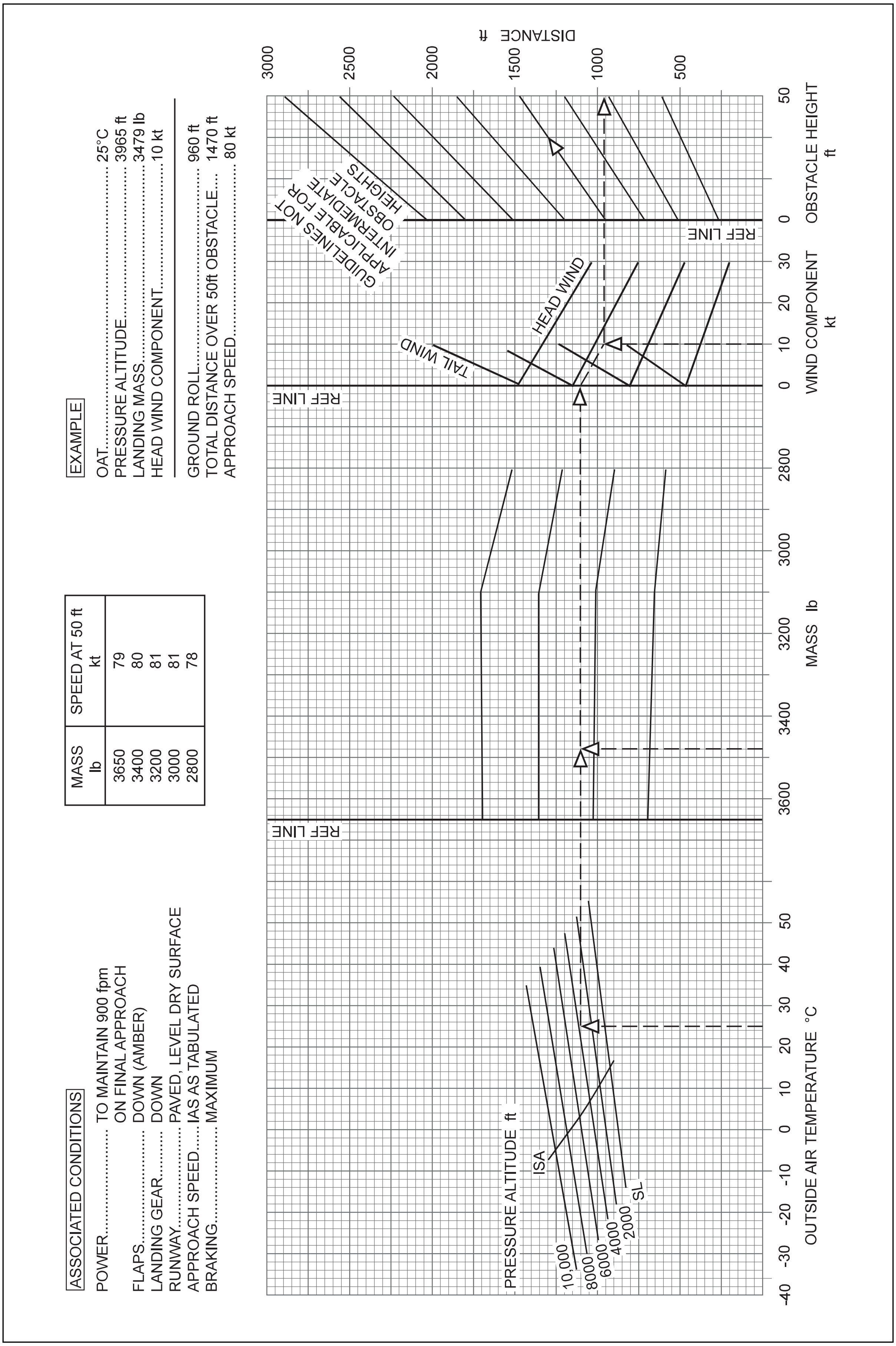


Figure 2.4 Landing

Section 3 Data for Multi-Engine Piston Aeroplane (MEP1)

1 General Considerations

1.1 Performance Classification

The specimen aeroplane is a low wing monoplane with retractable undercarriage. It is powered by twin, reciprocating, engines (both of which are supercharged). These drive counter-rotating, constant speed propellers.

The aeroplane, which is not certificated under CS/FAR 25, is a land-plane and is classified in Performance Class B.

1.2 General Requirements

This class of aeroplane includes all propeller-driven aeroplanes having 9 or less passenger seats and a maximum take-off weight of 5,700 kg or less. Performance accountability for engine failure, on a multi-engine aeroplane in this class, need not be considered below a height of 300 ft

1.3 Aeroplane Limitations

Structural Limitations
Maximum Take-Off Mass 4750 lb
Maximum Landing Mass 4513 lb

Runway Crosswind Limitation
Maximum Demonstrated Crosswind 17 kt

2 Take-Off

2.1 Requirements

There are two requirements for take-off with which compliance is necessary. They are the minimum field length and climb gradient requirements. The take-off climb requirements are considered in paragraph 3.

2.1.1 Field Length Requirements

a) When no stopway or clearway is available the take-off distance when multiplied by 1.25 must not exceed TORA.

b) When a stopway and/or clearway is available the take-off distance must:

i) not exceed TORA

ii) when multiplied by 1.3, not exceed ASDA

iii) when multiplied by 1.15, not exceed TODA

c) If the runway surface is other than dry and paved the following factors must be used when determining the take-off distance in a) or b) above:

Surface Type	Condition	Factor
Grass (on firm soil) up to 20 cm. Long	Dry	x 1.2
	Wet	x 1.3
Paved	Wet	x 1.0

d) Take-off distance should be increased by 5% for each 1% upslope. No factorisation is permitted for downslope.

NOTE: The same surface and slope correction factors should be used when calculating TOR or ASD.

2.2 Use of Take-Off Graphs

There are two sets of take-off graphs: one for a "normal" take-off with 0° flap and the other for a "maximum effort" (short field) take-off with 25° flap. Each set comprises two graphs, one for determining the take-off run and take-off distance, the other for calculating the accelerate-stop distance.

2.2.1 Distance Calculation

Procedure

To determine the distance used for take-off:

a) Select the appropriate graph.

b) Enter at the OAT. Travel vertically to the aerodrome pressure altitude.

c) From this point proceed horizontally right to the mass reference line. Parallel the grid lines to the appropriate take-off mass.

d) Continue horizontally right to the wind component reference line and parallel the grid lines to the wind component input

e) To read the appropriate distance:

  i) Continue horizontally from the wind component for TOR or ASD as appropriate to the graph used.

  ii) For take-off distance continue to the ground roll reference line then parallel the grid lines on Figure 3.1 or Figure 3.3, as appropriate.

f) Factorise for surface and slope.

Example:

Normal Take-Off	
Aerodrome Pressure Altitude	2000 ft
Ambient Temperature	+21°C
Take-Off Mass	3969 lb
Wind Component	9 kt Head
Runway Slope	1.5% Uphill
Runway Surface	Wet Grass
Aerodrome Field Lengths	Unbalanced

Calculate: Take-Off Distance Required

Solution: Graphical Distance 1,650 ft

Surface Factor = x 1.3
Slope Factor = x 1.075
Take-Off Distance = 2306 ft
Regulatory Factor = x 1.15
Take-Off Distance Required = 2652 ft

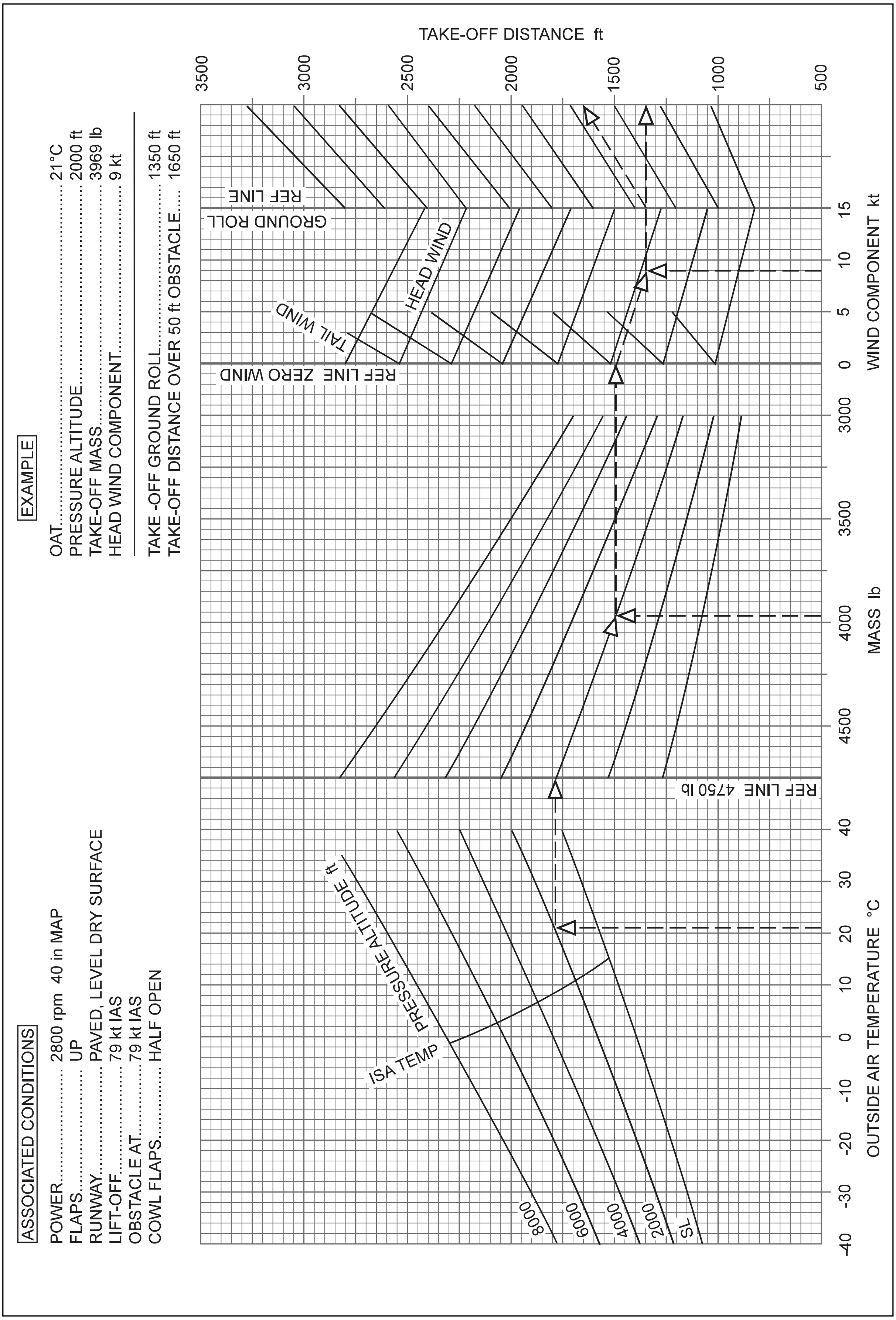


Figure 3.1 Take-Off – Normal Procedure

2.2.2 Mass Calculation

To calculate the field length limited take-off mass it is necessary to apply the requirements of JAR-OPS. Only the take-off distance graph is used but the right vertical axis is entered with shortest available de-factored distance. The factors to be considered are those of slope, surface condition and regulation. Examples are shown at page 6.

Procedure

a) Enter at the ambient temperature. Move vertically to the aerodrome pressure altitude.

b) From this point, travel horizontally right to the mass reference line. Mark this position with a pencil.

c) Enter the right vertical axis at the shortest available de-factored distance at the 50ft height. Parallel the grid lines to the ground roll reference line.

d) Now travel horizontally left to the appropriate wind component input. Parallel the grid lines to the wind component reference line.

e) From this point draw a horizontal line left through the mass grid.

f) From the position marked in b) above, parallel the grid lines to intersect the horizontal line from e) above.

g) At the intersection, drop vertically to read the field length limited TOM.

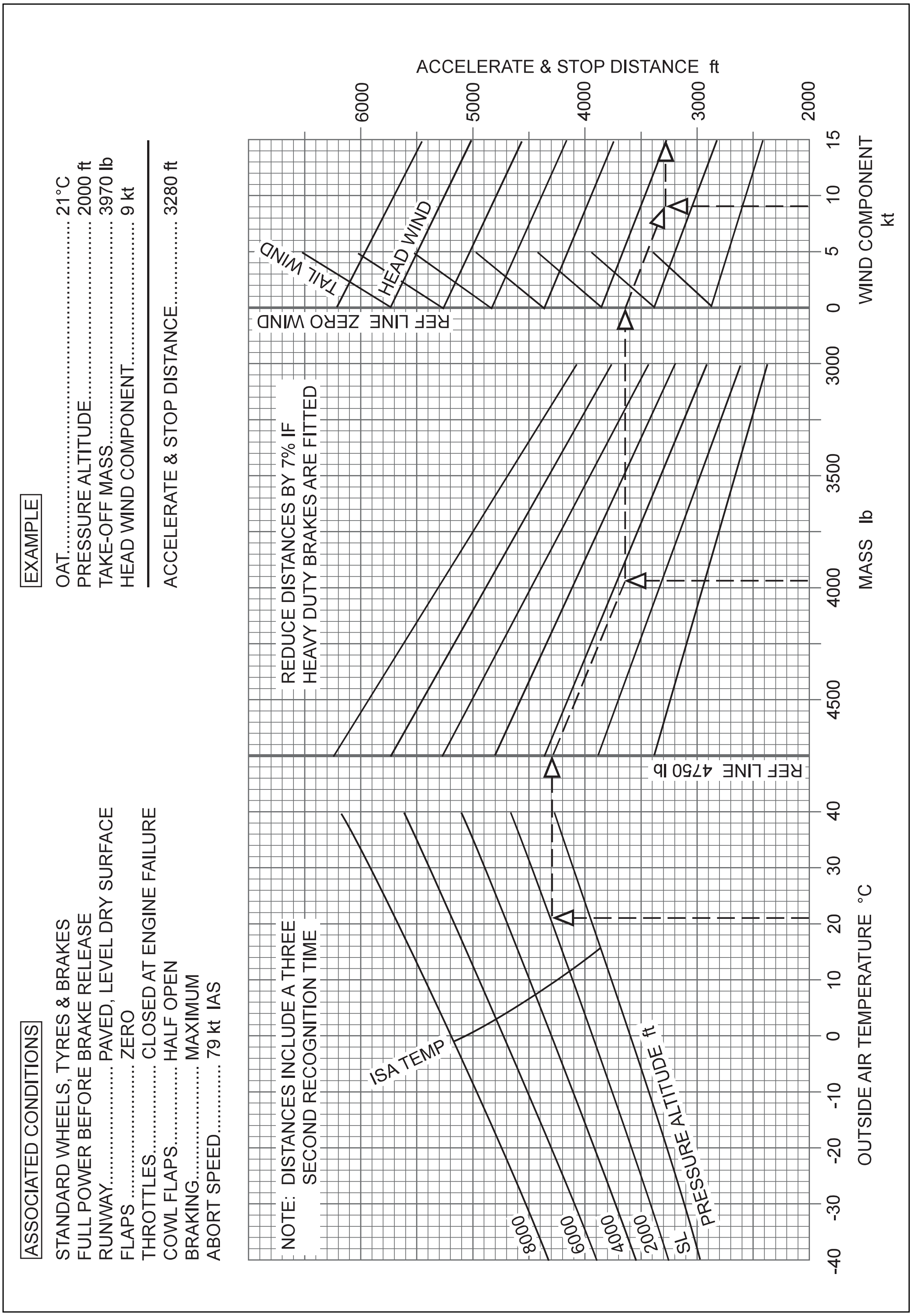


Figure 3.2 Accelerate/Stop Distance – Flaps 0°

Example 1: Maximum Effort Take-Off (Short Field) (Figure 3.3)

Normal Take-Off	
Aerodrome Pressure Altitude	2000 ft
Ambient Temperature	+30°C
Wind Component	5 kt Tail
Runway Slope	2 % Uphill
Surface Type	Grass
Surface Condition	Dry

TORA: 2,400 ft; ASDA: 2,500 ft; TODA: 2,600 ft

Calculate the field length limited take-off mass

Solution:

	TORA	ASDA	TODA
Given Distances	2400 ft	2500 ft	2600 ft
Slope Factor	1.1	1.1	1.1
Surface/Condition Factor	1.2	1.2	1.2
Regulation Factor	1.0	1.3	1.15
De-Factored Distance	1818 ft	1457 ft	1713 ft

Field Length Limited TOM 4000 lb, Using 1457 ft

Example 2: Normal Take-Off (Figure 3.1)

Aerodrome Pressure Altitude	4000 ft
Ambient Temperature	+20°C
Wind Component	5 kt Tail
Runway Slope	2% down
Surface Type	Concrete
Surface Condition	Wet
TORA: 2500 ft	No Stopway or Clearway

Calculate the field length limited take-off mass

Solution:

Given Distance	2500 ft
Slope Factor	÷1.0
Surface Condition Factor	÷1.0
Regulation Factor	÷1.25
De-factored Distance	2000 ft
Field Length Limited TOM	3100 lb Using 2000 ft

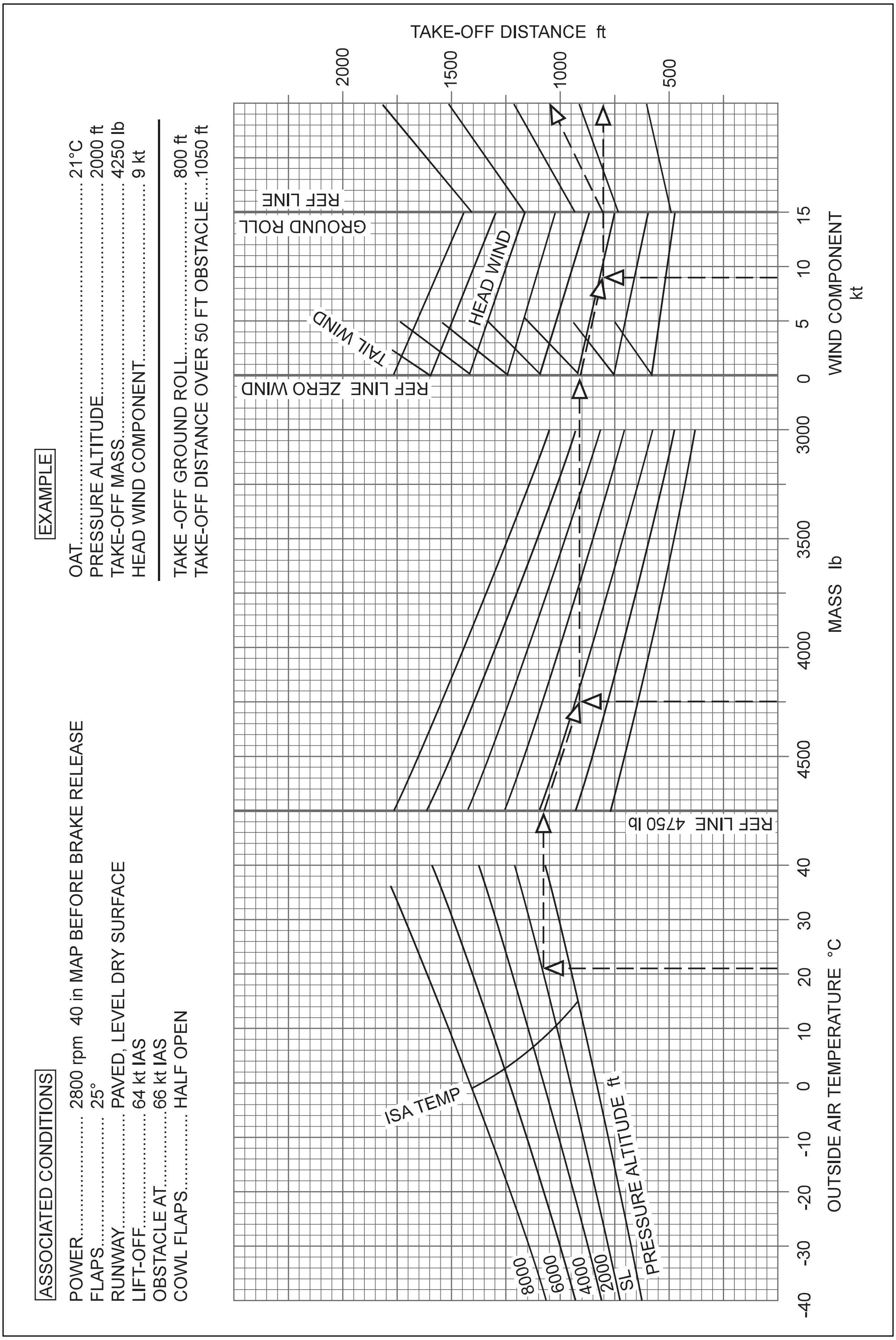


Figure 3.3 Take-Off – Maximum Effort

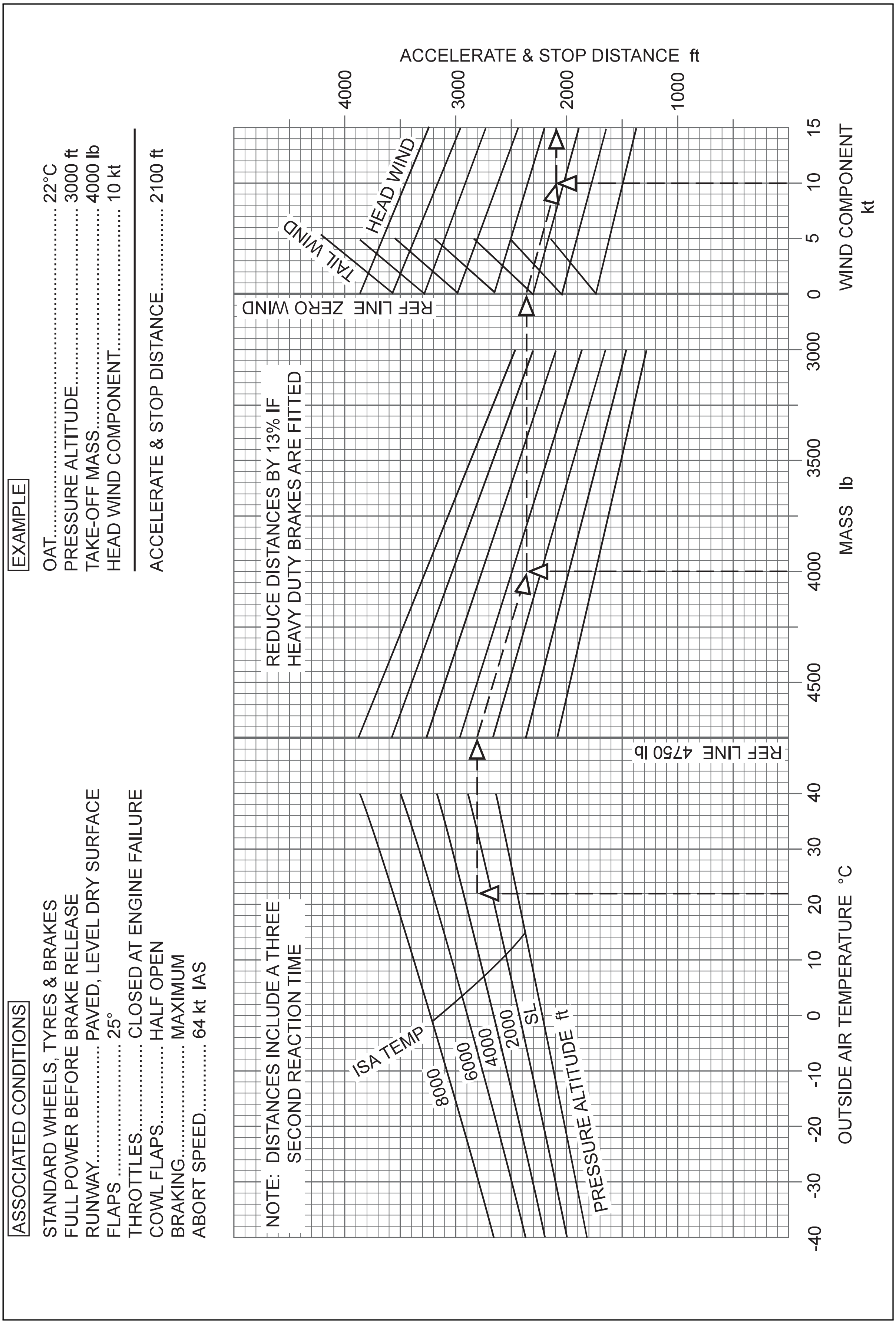


Figure 3.4 Accelerate/Stop Distance – Flaps 25°

3 Take-Off Climb

3.1 Requirements

The take-off climb requirements only apply to aeroplanes with two or more engines. The take-off climb extends from 50 ft above the surface at the end of TODR to 1500 ft above the same surface. The maximum take-off power setting is limited to 5 minutes from the commencement of the take-off climb, at which point it must be reduced to the maximum continuous power setting.

If visual reference for obstacle avoidance is lost, it is assumed that the critical power unit becomes inoperative at this point. All obstacles encountered in the accountability area must be cleared by a vertical interval of 50 ft

Turns are not permitted in the take-off climb before the end of the TODR and thereafter the angle of bank must not exceed 15°.

3.1.1 The Obstacle Accountability Area

The dimensions of the obstacle accountability area are as follows:

a) Starting semi-width at the end of TODA of 90 m, if the wing span is less than 60 m, then (60 m + ½ wing span) is the semi-width to be used.

b) The area expands from the appropriate semi-width, at the rate of 0.125 x D, to the maximum semi-width where D is the horizontal distance travelled from the end of TODA or TOD if a turn is scheduled before the end of TODA.

c) Maximum Semi-width

Condition	**Maximum Semi-width**	
Change of Track Direction	**0° to 15°**	**Over 15°**
Able to Maintain Visual Guidance or same Accuracy	300m.	600 m.
All Other Conditions	600 m	900 m.

3.1.2 Minimum Gradients of Climb

The minimum permissible gradients of climb, as specified in JAR-OPS 1, are:

a) All engines operating … 4% at screen height

b) One engine inoperative:

i) at 400 ft above the take-off surface level … measurably positive.

ii) at 1500 ft above the take-off surface level … 0.75%.

3.2 Use of Take-Off Climb Data

Because the graphs provided only permit the calculation of the rate of climb it is necessary to utilise the following formula to solve take-off climb problems:

$$\text{Time to Climb} = \frac{\text{Height Difference (ft)}}{\text{Rate of Climb (fpm)}} \times 60 \text{ seconds}$$

$$\text{Distance to Climb nm} = \frac{\text{Height Difference (ft)}}{\text{Rate of Climb (fpm)}} \times \frac{\text{Groundspeed (kt)}}{60}$$

$$\text{Still Air Gradient of Climb} = \frac{\text{Rate of Climb (fpm)}}{\text{TAS (kt)}} \times \frac{6000}{6080}\%$$

3.2.1 Climb graphs

There are three graphs provided for climb calculations:

a) Gear extended, maximum take-off power (Figure 3.5)

b) Gear retracted, maximum take-off power (Figure. 3.6)

c) Gear retracted, maximum continuous power (Figure 3.7)

NOTE: If a graph is used to show compliance with the obstacle clearance requirement, the gradient from 50 ft to the assumed engine failure height is to be the average all-engine gradient x 0.77. This is equivalent to the distance travelled with all engines operating x 1.3.

3.2.2 Use of Graph (Figure 3.5)

a) Enter with the temperature and travel vertically to the pressure altitude.

b) Travel horizontally to the curved graph line.

c) From this intersection drop a vertical line to the bottom scale. Read off rate of climb.

An example is shown on the graph.

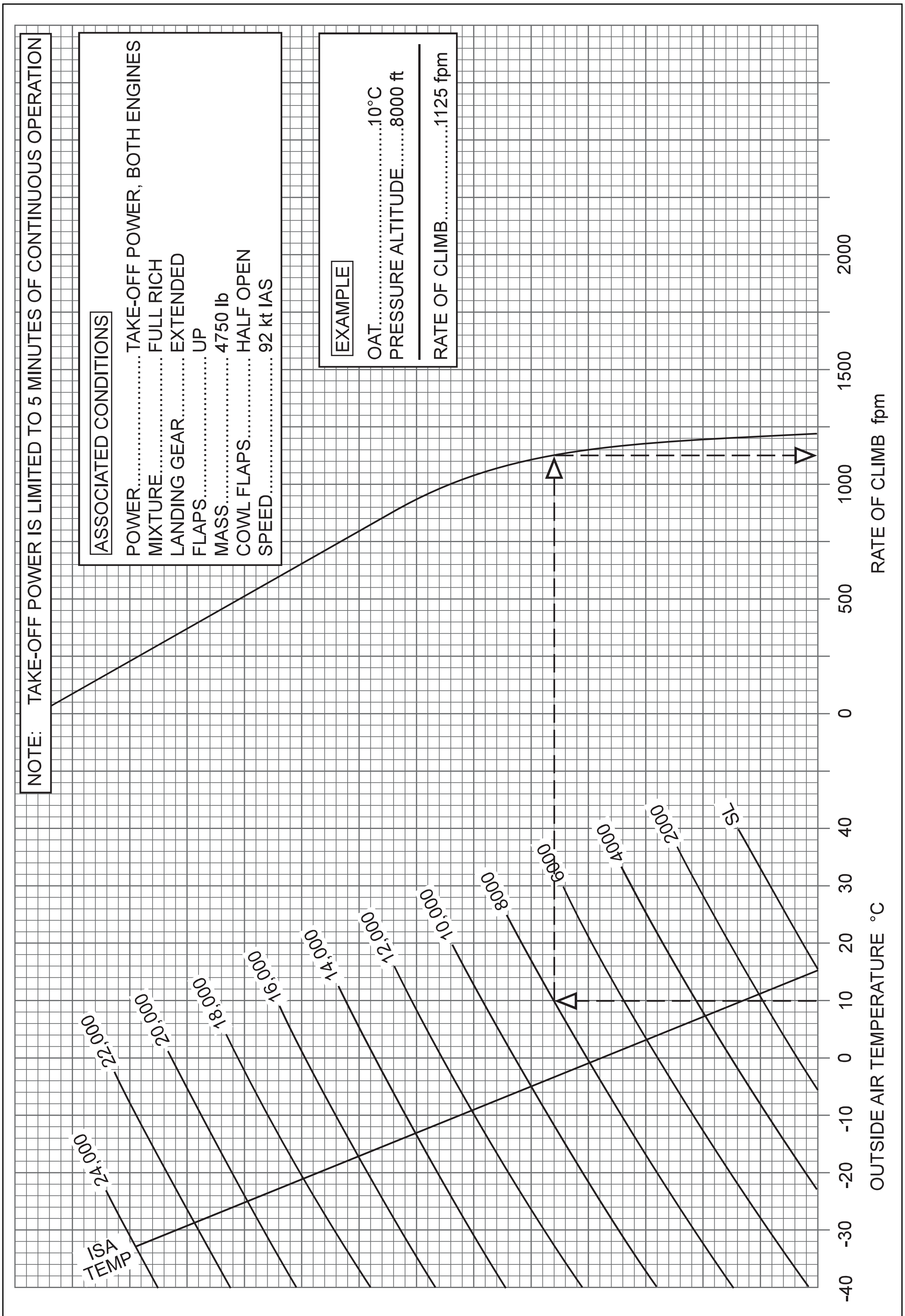


Figure 3.5 Take-Off Climb Performance – Gear Extended

3.2.3 **Use of Graphs (Figure 3.6 and Figure 3.7)**

a) Enter with OAT. Travel vertically to the pressure altitude.

b) From this point, travel horizontally right to intercept the interpolated value of take-off mass.

c) Drop vertically to read the all-engine-operating rate of climb.

d) From the TOM intersection, continue horizontally right to intercept the second interpolated weight (if applicable).

e) Drop vertically to read the one-engine-inoperative rate of climb.

Example 1:

Aerodrome Pressure Altitude	10000 ft
Ambient Temperature	+10°C
Take-Off Mass	4000 lb
Gear up (Undercarriage Retracted)	
Flaps 0°;	
Climb speed	92 kt IAS
Cloud Base	400 ft above Reference Zero
Wind Component	40 kt Head

Calculate the distance from the end of TODR to 1500 ft above Reference Zero for the purpose of obstacle clearance.

Solution:

All engines rate of climb at take-off power 1650 fpm
One engine inoperative rate of climb at take-off power 300 fpm
One engine inoperative rate of climb at MCP 220 fpm
Time to cloud base at take-off power = $\frac{350}{1650} \times 60 = 12.73$ seconds

Time to 1500 ft from cloud base at take-off power =
$\frac{1100}{300} \times 60 = 220$ seconds = 3 minutes 40 seconds.

Total time = 12.73 Seconds + 3 minutes 40 seconds = 3 minutes 52.73 seconds.
i.e. less than 5 minutes. Therefore Maximum Take-off Power can be maintained throughout the climb.

92 kt IAS = 110 kt TAS.

G/S = 110 = 20 = 90 kt (Using 50% of head wind component)

Distance to cloud base = $\frac{350}{1650} \times \frac{90}{60} \times 1.3 = 0.414$ NM

Distance cloud base to 1500 = $\frac{1100}{300} \times \frac{90}{60} = 5.5$ NM

Total Distance = 0.414 + 5.5 = 5.914 NM

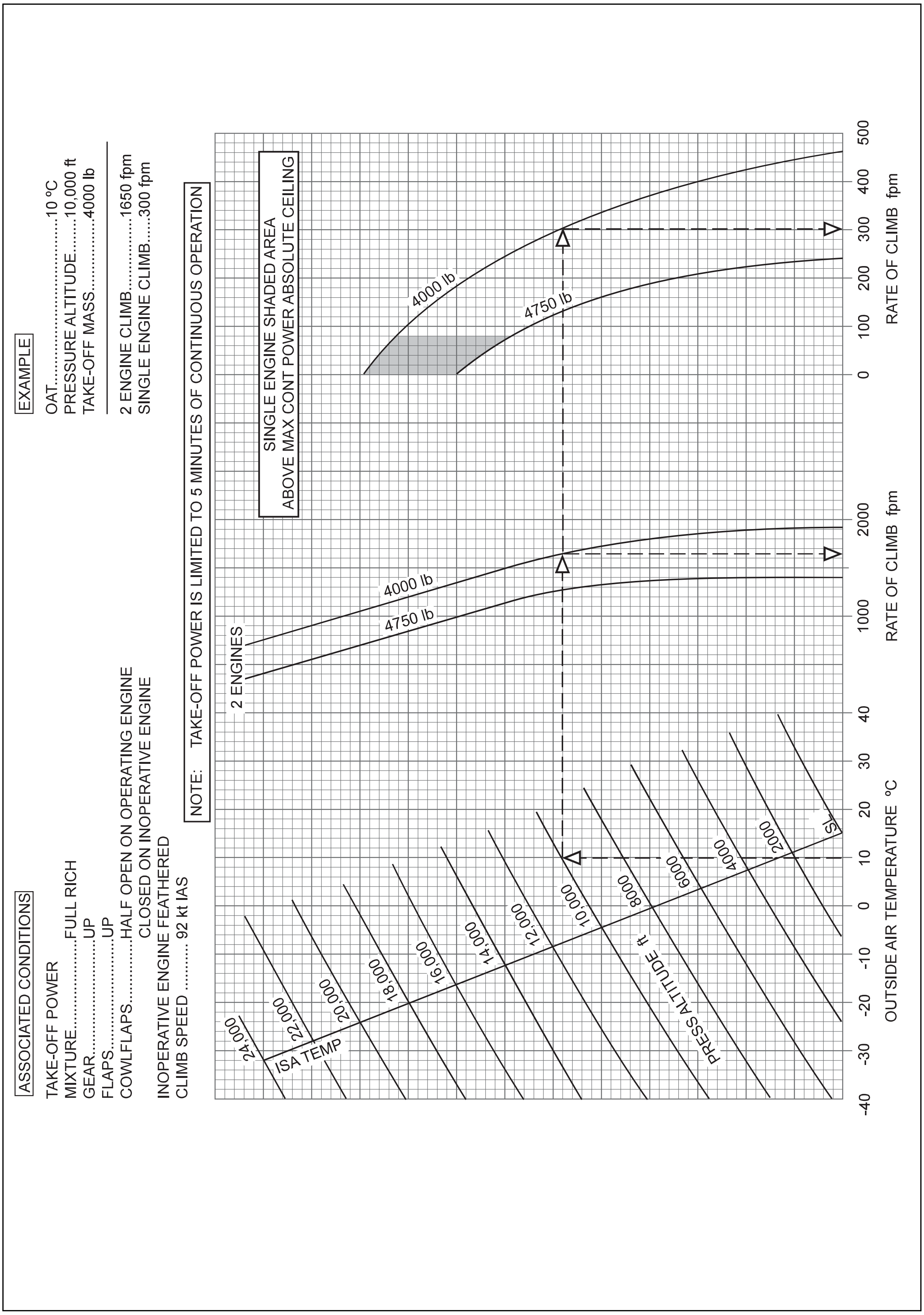


Figure 3.6 Take-Off Climb Performance – Gear Retracted

Example 2:

Aerodrome Pressure Altitude	6000 ft
Ambient Temperature	+20°C
Take-Off Mass	4500 lb
Gear up (Undercarriage Retracted)	
Flaps 0°	
Climb Speed	92 kt IAS
Cloud Base	400 ft above Reference Zero
Wind Component	13 kt Tail

Obstacle in the domain at 14000 ft from the end TODR and 600 ft above Reference Zero

Calculate the vertical clearance of the obstacle by the aeroplane.

Solution:

Figure 3.6 All engines rate of climb at take-off power 1510 fpm
Figure 3.6 One engine inoperative rate of climb at take-off power 255 fpm
Figure 3.7 One engine inoperative rate of climb at maximum continuous power 220 fpm

Time to cloud base $= \frac{350}{1510} \times 60 = 13.9$ seconds

Time to 1500 ft from cloud base =

$\frac{1100}{255} \times 60 = 258.8$ seconds = 4 minutes 18.8 seconds

Total time = 13.9 seconds + 4 minutes 18.8 seconds = 4 minutes 32.7 seconds. Therefore Maximum Take-Off power can be maintained throughout the take-off climb.

92 kt IAS = 104 kt TAS.

G/S = 104 + 20 = 124 kt (Using 150% of tailwind component rounded up)

Distance to cloud base $= \frac{350}{1510} \times \frac{124}{60} \times 6080 \times 1.3 = 3786$ ft

Distance cloud base to obstacle = 14000 - 3786 = 10214 ft

Height gain $= \frac{10214 \times 255 \times 60}{124 \times 6080} = 207.3$ ft

Height at obstacle = 400 + 207.3 = 607.3 ft

Clearance = 607.3 - 600 = 7.3 ft

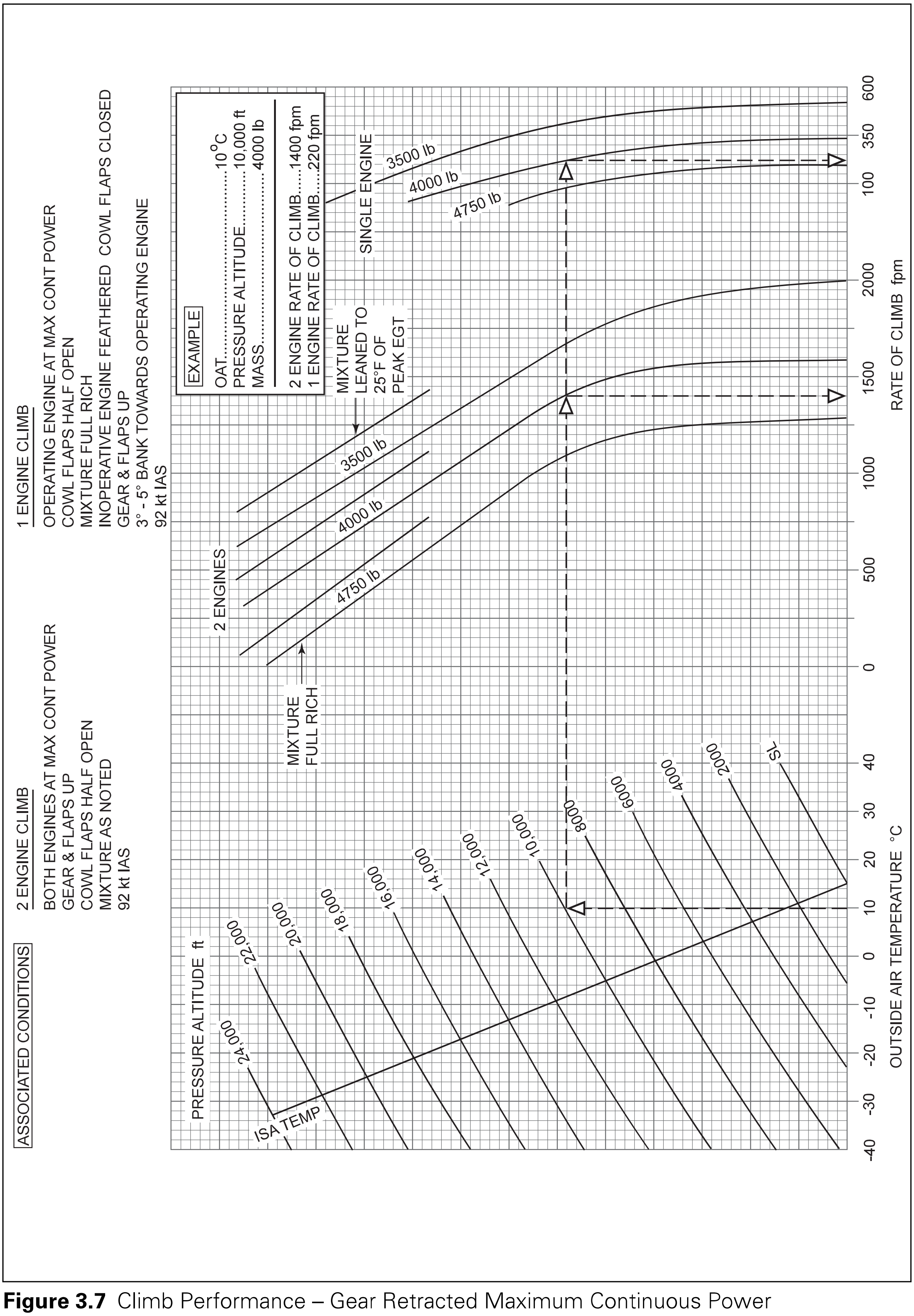


Figure 3.7 Climb Performance – Gear Retracted Maximum Continuous Power

4 En-route

The en-route phase extends from 1500 ft above the take-off surface level to 1000 ft above the landing aerodrome surface level.

4.1 Requirements

In the event of engine failure, with the remaining engine(s) set at the maximum continuous setting, the aeroplane must be able to continue flight at or above the relevant minimum safe altitude to an aerodrome at which the landing requirements can be attained.

To show compliance:

a) The aeroplane may not be assumed to be flying above that altitude at which the rate of climb is 300 fpm with all engines operating.

b) The one-engine-inoperative net gradient of climb is the gross gradient of climb decreased by 0.5%, or the net gradient of descent is the gross gradient of descent increased by 0.5%.

5 Landing

5.1 Requirements

There are three requirements for landing with which compliance is necessary. They are the climb gradient requirements in the event of a balked landing and a missed approach, and the landing field length requirement.

5.1.1 Field Length Requirements

a) The landing distance, from a screen height of 50 ft, must not exceed 70% of the landing distance available, i.e. a factor of 1.43.

b) If the landing surface is grass up to 20 cm long on firm soil, the landing distance should be multiplied by a factor of 1.15.

c) If the METAR or TAF or combination of both indicate that the runway may be wet at the estimated time of arrival, the landing distance should be multiplied by a factor of 1.15.

d) The landing distance should be increased by 5% for each 1% downslope. No allowance is permitted for upslope.

e) The despatch rules for scheduled (planned) landing calculations are in JAR-OPS 1.550 (c).

5.1.2 Balked Landing Requirements

The minimum acceptable gross gradient of climb after a balked landing is 2.5%. This must be achieved with:

a) The power developed 8 seconds after moving the power controls to the take-off position.

b) The landing gear (undercarriage) extended.

c) Flaps at the landing setting.

d) Climb speed equal to V_{REF}.

5.1.3 Missed Approach Requirements

The minimum acceptable gross gradient of climb, after a missed approach, is 0.75% at 1500 ft above the landing surface. This must be achieved with:

a) The critical engine inoperative and the propeller feathered.

b) The live engine set at maximum continuous power.

c) The landing gear (undercarriage) retracted.

d) The flaps retracted.

e) Climb speed not less than 1.2 V_{S1}.

Example: Flaps Up

Aerodrome Pressure Altitude	=	6000 ft
Ambient Temperature	=	+10°C
Aeroplane Mass	=	4000 lb

Calculate the missed approach gradient of climb:

Solution: Use Figure 3.7: One-engine-inoperative grid

True Airspeed	=	102 kt
Rate of Climb	=	300fpm
Gradient of Climb	=	$\frac{300}{102} \times \frac{6000}{6080} = 2.9\%$

5.2 Balked Landing Climb Graph

The graph provided for this purpose is constructed for the maximum landing mass of 4513 lb (Figure 3.8).

Use of Graph:

a) Enter at the ambient temperature. Travel vertically to the aerodrome pressure altitude.

b) From this point travel horizontally right to intercept the rate of climb graph line. Now drop a vertical to read the rate of climb.

c) Convert the rate of climb to a still-air gradient of climb using the formula:

$$\text{Still Air Gradient of Climb} = \frac{\text{ROC (fpm)}}{\text{TAS (kt)}} \times \frac{6000}{6080}\ \%$$

Example:

Aerodrome Pressure Altitude	3000 ft
Ambient Temperature	+22°C

Solution:

Graphical ROC	=	810 fpm.
IAS 85 kt	=	91 kt TAS
Climb Gradient	=	$\frac{810}{91} \times \frac{6000}{6080} = 8.78\%$

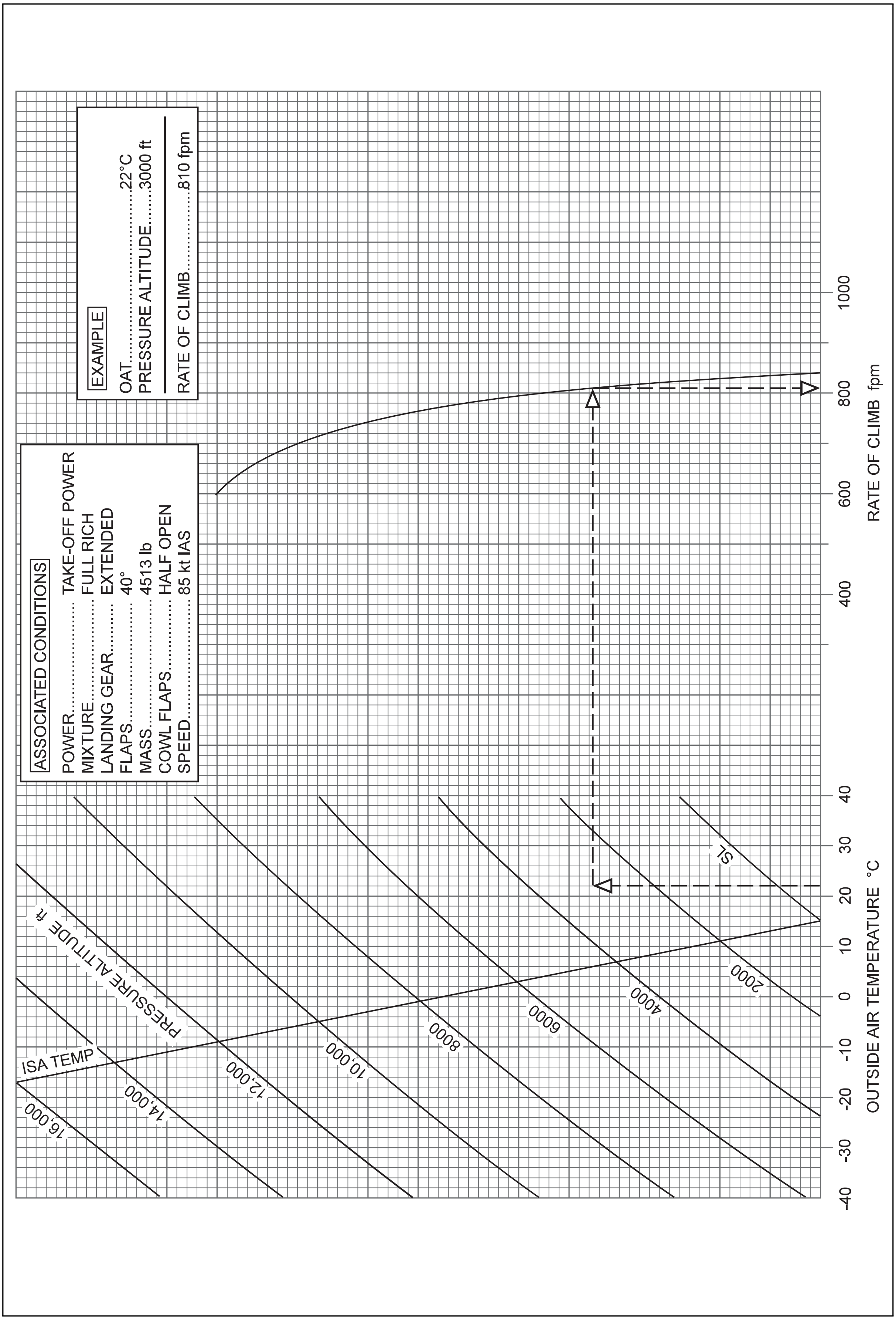


Figure 3.8 Balked Landing Climb Performance

5.3 Use of Landing Field Length Graphs

There are two landing field length graphs: one for normal landings with 40° landing flap (Figure 3.9), and the other for short field landings with 40° landing flap. (Figure 3.10).

5.3.1 Distance Calculations

a) Enter at the ambient temperature. Move vertically to the aerodrome pressure altitude.

b) From this point, move horizontally right to the landing weight reference line. Parallel the grid lines to the appropriate landing mass input.

c) Continue from this intersection to the wind component reference line. Parallel the grid lines to the appropriate wind component input.

d) Travel horizontally right to the ground roll reference line. Either continue horizontally to the right vertical axis to read the ground roll distance or parallel the grid lines to the right vertical axis to read the landing distance from 50 ft.

e) Apply the appropriate factors to the landing distance to obtain the landing distance required.

Example: Normal Landing

Aerodrome Pressure Altitude	3000 ft
Ambient Temperature	+22°C
Landing Mass	3650 lb
Wind Component	10 kt Head
Runway Slope	1% Down
Runway Surface	Grass
Runway Condition	Wet

Calculate Landing Distance Required

Solution:

Graphical Distance	2220 ft
Slope Correction Factor	x 1.05
Surface Correction Factor	x 1.15
Condition Correction Factor	x 1.15
Regulatory Factor	x 1.43
Landing Distance Required	= 4408ft

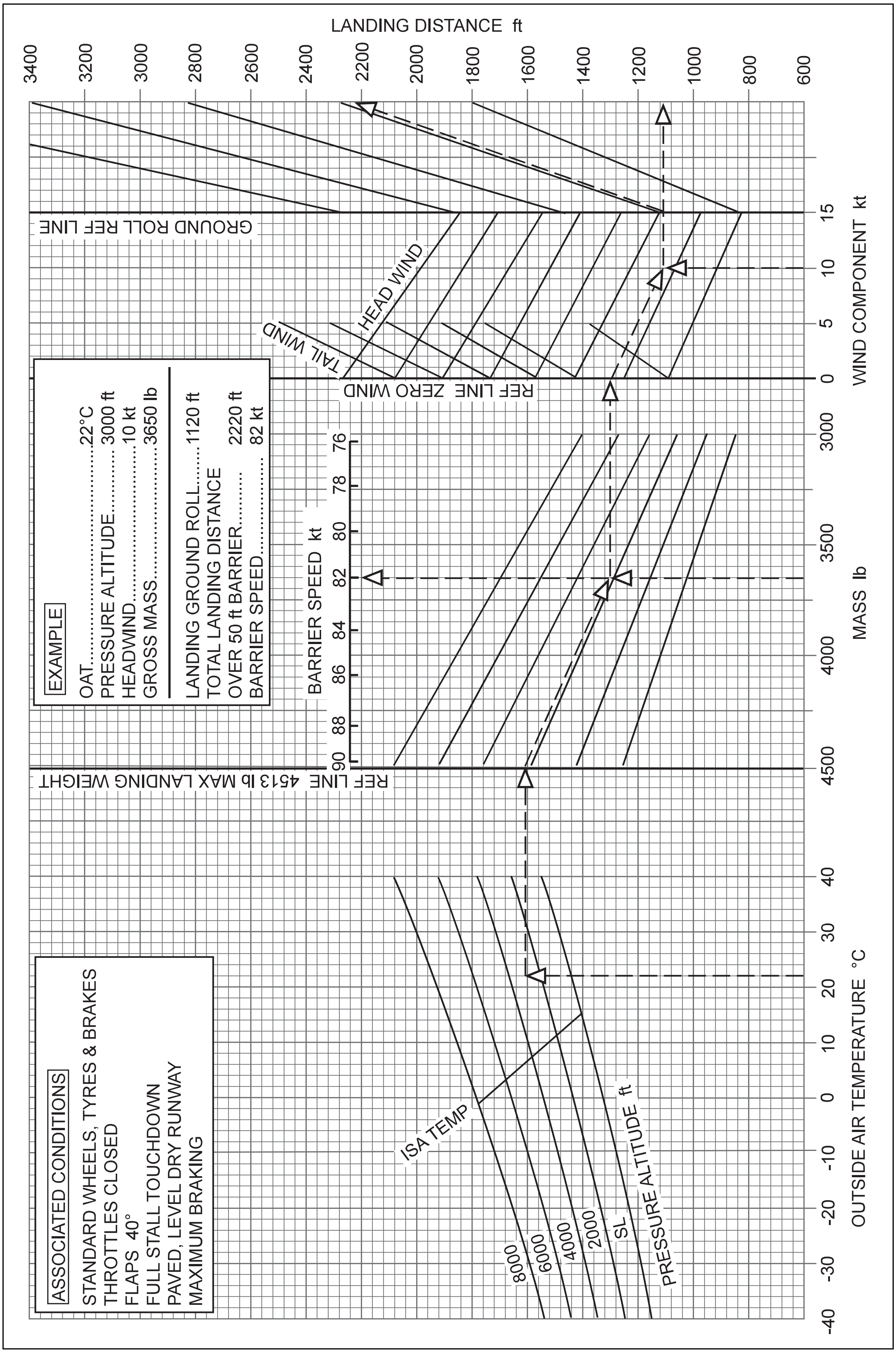


Figure 3.9 Landing Distance Normal Procedure

5.3.2 Landing Mass Calculations

The procedure for calculating the field length limited landing mass is:

a) De-factorise the landing distance available by dividing by the slope correction factor, the surface type correction factor, the surface condition correction factor and the regulatory factor.

b) Enter at the ambient temperature. Move vertically to the aerodrome pressure altitude.

c) From this point, travel horizontally right to the mass reference line. Mark with a pencil.

d) Enter right vertical axis with the distance from a) above. Parallel the grid lines to the ground roll reference line.

e) From this point, travel horizontally left to the appropriate wind component input. Parallel the grid lines to the wind component reference line.

f) Now draw a line horizontally from this point through the mass grid.

g) From the pencil mark in c) above, parallel the grid lines to intersect the horizontal line. Drop vertically to read field length limited landing mass.

Example: Short Field Landing

Aerodrome Pressure Altitude	3000 ft
Ambient Temperature	+22°C
Landing Distance Available	3733 ft
Wind Component	10 kt Head
Runway Slope	1% down
Runway Surface	Grass
Runway Condition	Wet

Calculate the field length limited landing mass

Solution:

Landing Distance Available	3733 ft
Slope Correction Factor	÷1.05
Surface Type Correction Factor	÷1.15
Surface Condition Correction Factor	÷1.15
Regulatory Factor	÷1.43
De-factorised LDA	= 1880 ft
Field Length Limited Landing Mass	= 3800 lb

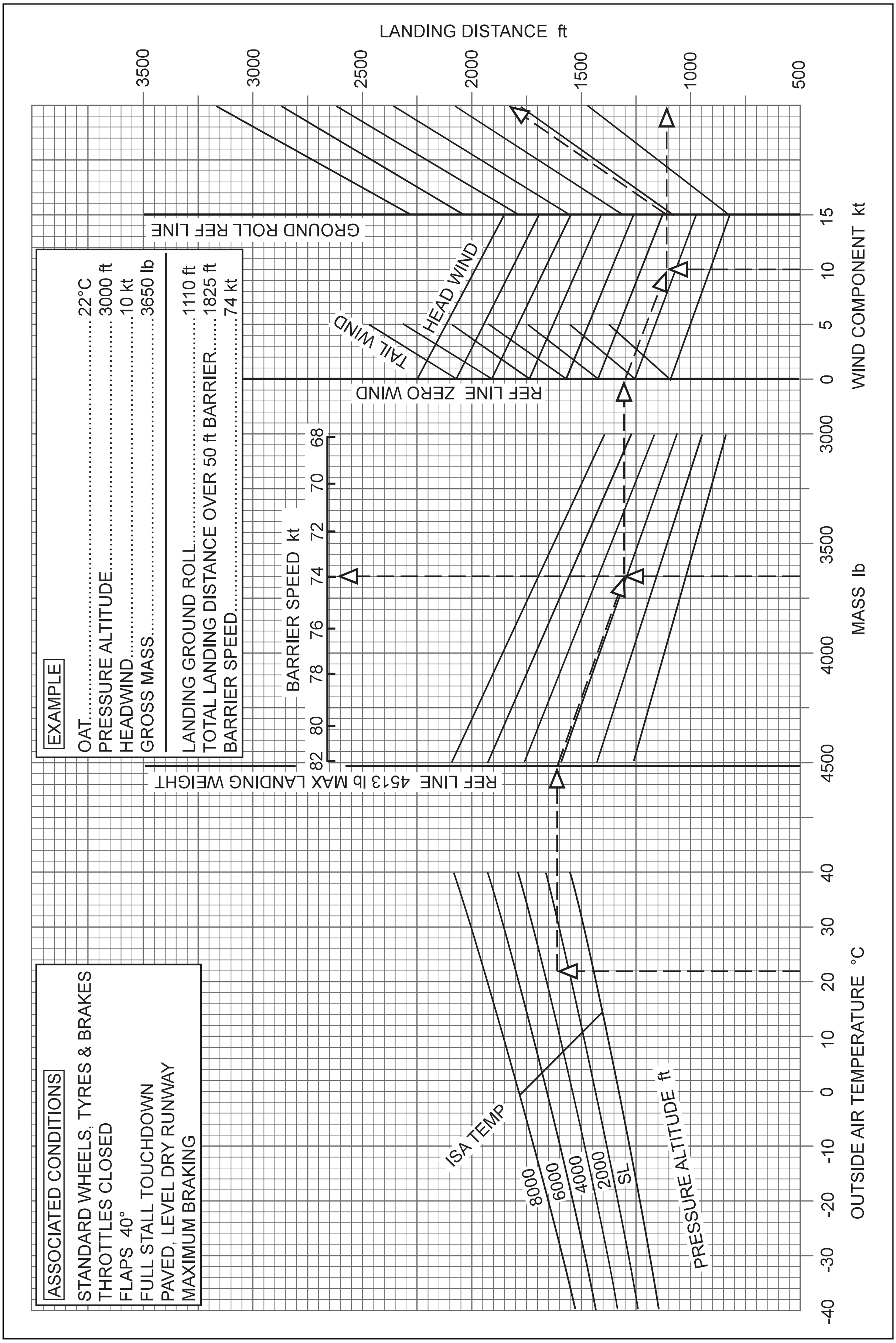


Figure 3.10 Landing Distance Short Field