PART 8 - APPROACH AND LANDING

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INTRODUCTION

This part presents performance data for normal and tactical landings on both paved and unpaved runways. Landing performance is based on flaps LNDG (23°) deflection, all engines operating.

Normal landings is done with threshold speeds at V_{MCL} or 1.23 V_{SR} (whichever is higher) and reverse power when airplane on ground.

Tactical landings, or short field landings, utilize the maximum landing performance obtainable under a military emergency procedure. The landing is done with reduced threshold speeds (1.13 V_{SR}) to obtain the fewer landing ground roll and landing distance.

DEFINITIONS APPLICABLE TO LANDING

Approach Speed (V_{APP})

It is the minimum recommended speed at which the final approach phase should be performed.

Threshold Speed (V_{TH})

The aircraft speed at 50 ft above the landing surface.

Reference Speed (V_{REF})

The minimum recommended threshold speed for landings with 23° flaps setting.

Touchdown Speed (V_{TD})

The speed at which the main landing gear touches the ground.

Landing Ground Rolll

It is the horizontal distance from the point of touchdown to the point at which the aircraft is fully stopped, with all engines operating.

Landing Distance from 50 feet

This is the horizontal distance from the 50 feet AGL point to the point at which the aircraft is fully stopped, with all engines operating.

TYPE OF RUNWAY SURFACE (RCR)

The basic landing performance data shown in this part is only valid for a paved and dry runway. However, correction grids are provided showing the increase in distances required when the aircraft is operated on unpaved runways or paved hard runways partially or completely covered with water, snow or ice.

Ground performance data for unpaved surfaces are applicable either hard runway surfaces (CBR value of at least 7, and a nodulus of soil reaction, K, of at least 180 pci) or soft runway surfaces (CBR value up to 2 and a nodulus of soil reaction, K, up to 50 pci).

The RCR parameter is used in the correction grids:

- Runway condition reading (RCR) is a value related to the average braking effectiveness of the aircraft on a particular runway surface. The recommended RCR value is used when scheduling any performance which involves braking, such as critical field length, refusal speed and landing distances.

  In compliance with ICAO recommendations, paved runway surface braking conditions are reported by civil airport authorities by means of the "Good/Medium/Poor" categorization of braking action. When a RCR value is not available for a given paved runway, the table below may be used to obtain an acceptable RCR value to be used in the RCR corrections grids.

PAVED RUNWAY CONDITION	ICAO REPORT	RCR
Dry	Good	23
Wet	Medium	12
Icy	Poor	5

  On unpaved runways, an equivalent RCR value appropriate to the roughness characteristics of the runway surface is recommended below.

Type of unpaved runway surface	Equivalent RCR
Smooth surface	16
Wavy surface	10

  Full unrestricted braking can be achieved on smooth unpaved runways. For these runways, a value of 16 units of equivalent RCR is recommended.

NOTE

Always use an equivalent RCR value of 10 (i.e., wet or mowed grass runways, stubble fields, in the presence of runway undulations which are known to prevent full unrestricted braking,or when the braking effectiveness deteriorates on way unpaved runways due to the necessary modulation of the brakes application in order to avoid excessive nose pitch oscillations), unless assured that the unpaved runway roughness features are smooth enough to allow full unrestricted braking, in which case in equivalent RCR value of 16 can be used instead.

WIND APPLICATION TO THE LANDING

WIND DEFINITIONS

The following definitions are used in the application of winds:

Steady wind value:	Reported steady wind.
Gust increment:	Reported wind in excess of steady wind value.
Headwind component:	Effective wind parallel to the runway, determined from the steady wind value and blowing in the direction opposite to landing.
Tailwind component:	Effective wind parallel to the runway, determined from the steady wind value plus the gust increment and blowing in the direction of landing.
Crosswind component:	Effective wind 90° across the runway, determined from the steady wind value plus the gust increment.

WIND DIRECTION AND VELOCITY

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

ACCOUNTING FOR WIND

The landing, data presented in this part are based on unfactored reported winds measured at 10 meters above the landing surface.

The conservative approach is to accept the benefits of headwinds as an increased safety margin; for example, consider the use of the headwind only when necessary for mission accomplishment. When it is necessary to use the headwind, it may be decided even then to take only partial benefit. In such a case it is recommended that 50% of the headwind component and 150% of the tailwind component be applied. If the conservative approach is used, it is important to remember the following:

1. No correction for headwind should be made to any distance or speed.
2. Apply tailwinds.
3. Threshold speed must be corrected for crosswind.

When the nonconservative approach is used, all landing must be corrected for headwins or tailwinds during landing planning. Additionally, threshold speed must be corrected for crosswinds.

The tailwind component should always be applied. In this case it is recommended that 150% of the tailwind component be applied.

Wind Summary Table

TYPE OF WIND	HOW TO OBTAIN THE COMPONENT	USE OF THE WIND COMPONENT
Headwind	Enter the landing wind components graph with the steady wind value to obtain runway component.	Use 50% of the runway component for all the landing distances.
Tailwind	Enter the landing wind components graph with the steady wind value plus the gust increment to obtain runway component.	Use 150% of the runway component for all the landing distances.
Crosswind component	Enter the landing wind components graph with the steady wind value plus the gust increment to obtain crosswind.	Check the necessity of increased threshold speeds.

WIND COMPONENTS IN LANDING

The graph in Figures 8-1 and 8-2 are used to determine the wind components in the landing (headwind or tailwind and crosswind) for wind angles (with respect to the runway) of 0° to 180° and wind speeds of 0 to 60 knots. The graph in Figure 8-1 is applicable to normal landings and graph in Figure 8-2 is for tactical landings.

The graph also includes the minimum threshold speed at 50 ft. This value represents the minimum speed for various crosswind components.

If the intersection point of the planned threshold airspeed and the crosswind component is not in the recommended area (Figure 8-1 and Figure 8-2), increase the threshold airspeed until the recommended area is reached or until the airspeed has increased 15 knots, whichever gives the lower airspeed.

If the recommended area has not been reached after increasing the airspeed 15 knots and in the caution area, caution should be exercised during landing.

If the caution area has not been reached after the speed has been increased, the landing is not recommended due to the fact that a high degree of pilot skill is required for crosswind correction.

In case that flaps LNDG (23°) require to operate the aircraft out of recommended area it is possible to use flaps APP (15°) position to accomplish the landing (Figure 8-1).

For crosswinds above 20 Knots refer to "Operation in Strong Crosswinds", section 2.

Use of Graph

Enter chart with steady wind value and wind angle to determine headwind component (read on left hand vertical scale).

Enter chart with steady wind value plus the gust increment to determine both tailwind component (read on left hand vertical scale) and crosswind component (read on horizontal scale).

Enter chart with crosswind component and planned threshold speed (on right hand vertical scale) in order to check in which area (recommended/caution/not recommended) the intersection point falls. If this intersection point is in the not recommended area, move vertically upwards following the procedure described in last paragraph above.

AIR MINIMUM CONTROL SPEED

Air minimum control speed is the minimum airborne speed at which the engine most critical to directional control can fail, with the remaining engine operating go around power and a straight flight path at that speed can be maintained with full rudder deflection, and no more than 75% of the available aileron control or 5° bank.

Figure 8-3 presents the air minimum control speed with landing configuration (V_{MCL}) for flaps LNDG (23°) and APP (15°). This graph is applicable to normal and tactical landing.

V_{MCL} is based on flight tests, applying the following conditions:

- Most unfavorable position of the center of gravity.
- Go around power (APR).
- ECS off.
- Engine Anti-ice: off.
- Rudder pedal force less than 180 pounds.

Use of Graph

Enter the graph with the ambient temperature, move vertically upwards to the pressure altitude curve and horizontally to the left. Read the air minimum control speed on the vertical scale.

Example

Given:

1. Ambient temperature: 6°C
2. Pressure altitude: 2.000 ft

Results:

1.	V_{MCA} (Figure 8-3)	96 KIAS

NORMAL LANDING

Normal landing is the landing performed at the landing reference speed of 1.23 V_{SR} with flaps LNDG (23°) position.

LANDING SPEEDS

The various operational speeds used during normal landing are given in Figure 8-4. These speeds are:

- Approach Speed (V_{APP}): is the higher of V_{REF} + 10 KIAS or V_{MCL} + 5 KIAS for an approach with flaps APP (15°) setting.
- Landing Reference Speed (V_{REF}): is the minimum threshold speed for normal landing (the higher of 1.23 V_{SR} of V_{MCL}).
- Touchdown Speed (V_{TD}): is the higher of 1.18 V_{SR} or V_{MCL} - 6 KIAS, based on flight tests. This value may be different during operations due to pilot technique in landing flare.

Use of Graphs

Enter the corresponding graph with the aircraft weight and move vertically upwards until the corresponding curve for each of the landing speeds is intersected. From each point of intersection, move horizontally towards the left. Read the corresponding value of each speed in the vertical scale.

Example

Given:

1. Aircraft landing weight: 16000 Kg
2. Flaps: 23°
3. Ambient temperature: 6°C
4. Pressure altitude: 2.000 ft
5. Normal landing

Results:

1.	V_{TD} (Figure 8-4)	93 KIAS
2.	V_{REF} (Figure 8-4)	100 KIAS
3.	V_{MCA} (Figure 8-3)	96 KIAS
4.	V_{APP} the higher of 100+10 or 96+5, flaps 15°	110 KIAS

LANDING DISTANCE AND LANDING GROUND ROLL

For the flaps LNDG (23°) position, normal landing, 2 engines operative, Figure 8-5 presents the landing ground roll as a function of the airfield ambient temperature, airfield pressure altitude and aircraft weight. Also correction graphs are given for corrections due to increase threshold speeds, engine operation at ground idle (instead of full reverse), runway slope, wind speed and RCR.

For the flaps LNDG (23°) position, normal landing, 2 engines operative, Figure 8-6 gives the landing distance from 50 ft as a function of the airfield ambient temperature, airfield pressure altitude and aircraft weight. Also, the correction graphs mentioned in the previous paragraph are given.

Use of Graphs

Figure 8-5 and Figure 8-6. Enter the graph (Sheet 1 of 2) with the airfield ambient temperature, move horizontally towards the right to the airfield pressure altitude curve and vertically downwards to the aircraft weight curve. From this point move horizontally towards the right and read the uncorrected landing ground roll or the uncorrected landing distance from 50 ft.

Enter the graph with the previous value of Sheet 1. If the correction for increased threshold speed at 50 ft (Sheet 2 of 2) is applicable, move parallel to the guidelines to the threshold speed increase and, from there, horizontally towards the right to the next reference line. If the correction is not applicable, move horizontally towards the right to the next reference line.

If the correction for engine operation at ground idle is applicable, move parallel to the guidelines to the vertical scale and, from there, horizontally towards the right to the next reference line. If the correction for engine operation at ground idle is not applicable move horizontally towards the right, to the next reference line.

From this point move parallel to the guidelines (upwards: positive slope; downwards: negative slope) to the runway gradient and horizontally towards the right, to the next reference line:

From this point, move parallel to the guidelines (downwards: headwind; upwards: tailwind) to the wind speed and horizontally towards the right to the next reference line.

From this point, move parallel to the guidelines to the value of RCR applicable to runway surface and horizontally towards the right. Read on the vertical scale the corrected landing ground roll (Figure 8-5, Sheet 2 of 2) or the corrected landing distance from 50 ft (Figure 8-6, Sheet 2 of 2).

Example

Given:

1. Airfield ambient temperature: 14°C.
2. Airfield pressure altitude: 5000 ft.
3. Aircraft weight: 19000 Kg.
4. V_{TH} increase: 12 KIAS.
5. Power setting on ground: Ground idle.
6. Runway slope: +2.3%.
7. Wind speed: 52 knots headwind (on the chart, 50% of this value will be used, i,e, 26 knots).
8. RCR: 12.
9. Normal landing, flaps 23°.

Results:

1.	Corrected landing ground roll (Figure 8-5)	1400 ft
2.	Corrected landing distance from 50 ft (Figure 8-6)	2675 ft

LANDING WITH A FLAP SETTING LESS THAN 23º

When operational or flap system failure dictate that a landing be performed at other than the flaps LNDG (23°) normal configuration, proceed as follows, to determine the value of the landing speeds and the landing distances:

- Approach speed (V_{APP}).

  $V_{APP} = V_{TH} + \Delta V_{flap}$

- Threshold speed (V_{TH}).

  $V_{TH} = V_{REF} + \Delta V_{flap}$

  where ΔV_{flap} get the values as a function of flaps configuration:

Flap setting	ΔV_{flap} (KIAS)
APP (15°)	10
TO (10°)	15
UP (0°)	25

- Landing ground roll: increase the value obtained in Figure 8-5 with the percentage of the following table to obtain the landing ground roll with several flap positions.
- Landing distance from 50 ft: increase the value obtained in Figure 8-6 with the percentage of the following table to obtain the landing distance from 50 ft with several flap positions.

Flap setting	Landing ground roll	Landing distance from 50 ft
APP (15°)	20%	10%
TO (10°)	27%	15%
UP (0°)	40%	25%

TACTICAL LANDING

Tactical landings, or short field landings utilize the maximum landing performance obtainable under a military emergency procedure.

LANDING SPEEDS

The various operational speeds used during tactical landing are given in Figure 8-7. These speeds are:

- Approach speed (V_{APP}): equal to normal operation.
- Threshold speed (V_{TH}): 1.13 V_{SR} (flaps LNDG).
- Touchdown speed (V_{TD}): 1.10 V_{SR} (flaps LNDG). This value may be different during operations due to pilot technique in landing flare.

Use of Graphs

The use of the graphs is similar to the corresponding graph for normal landing.

LANDING DISTANCE AND LANDING GROUND ROLL

For the flaps LNDG (23°) position, tactical landing, 2 engines operative, Figure 8-8 presents the landing ground roll as a function of the airfield ambient temperature, airfield pressure altitude and aircraft weight.

Also correction graphs are given for corrections due to increase threshold speed, engine operation at ground idle (instead of full reverse), runway slope, wind speed and RCR.

For the flaps LNDG (23°) position, tactical landing, 2 engines operative, Figure 8-9 gives the landing distance from 50 ft as a function of the airfield ambient temperature, aircraft pressure altitude and aircraft weight. Also, the correction graphs mentioned in the previous paragraph are given.

Use of Graphs

The use of the graphs is similar to the corresponding graph for normal landing.

MAXIMUM BRAKE ENERGY SPEED

The maximum brake energy speed (V_{MBE}) is the highest speed from which the aircraft can be brought to a stop without exceeding the maximum energy absorption capability of the brakes.

The chart of Figure 8-10 gives the total energy absorbed by brakes as a function of the landing weight, threshold speed, airfield pressure altitude, airfield ambient temperature, runway slope, wind speed and power setting. The certified maximum energy for the brakes, either takeoff and lading is 37.32 MJ. The graph can be used in 2 ways:

1. Direct form: Obtain, for given conditions, the energy absorbed by brakes for a landing done at a determined threshold speed and know if the certified maximum has been exceeded.
2. Inverse form: Determine, for given conditions, the maximum threshold speed (V_{TH}).

Use of Graphs

Direct form:

Enter the graph with the landing weight, move vertically upwards until the threshold speed curve is reached and then towards the right to the first reference line. Move parallel to the guidelines until the pressure altitude is reached and towards the right to the next reference line. Move parallel to the guidelines until the ambient temperature is reached and then toward the right to the next reference line. Move parallel to the guidelines (upwards: negative slope; downwards: positive slope) until the runway slope is reached and then towards the right to the next reference line. Move parallel to the guidelines (upwards: tailwind; downwards: headwind) and then towards the right to the next reference line. If the ground idle power is applicable, move parallel to the guidelines until the vertical scale is reached. Read the value of the total brake energy absorbed by brakes on the vertical scale.

Inverse form:

Enter the graph by the energy scale and proceed to inverse manner that explained before.

Example

1. Landing weight: 20000 kg.
2. Threshold speed: V_{REF}.
3. Pressure altitude: 10000 ft
4. Airfield ambient temperature: -15°C and runway slope +1%.
5. Wind speed: 40 knots headwind (on the chart, 50% of this value will be used, i.e. 20 knots).
6. Power setting on ground: Ground idle.

Results:

1. Total brake energy absorption (Figure 8-10) 17 MJ
2. Maximum energy for normal landing is not exceeded.

LANDING CROSSWIND CHART
NORMAL LANDING

DATE:	JUL. 2000	**AIRCRAFT:**	C-295M	**FLAPS:**	APP (15º) and LNDG (23º)
DATA BASIS:	FLIGHT TEST	**ENGINES:**	PW 127-G		
		PROPELLERS:	HS 568F-5		

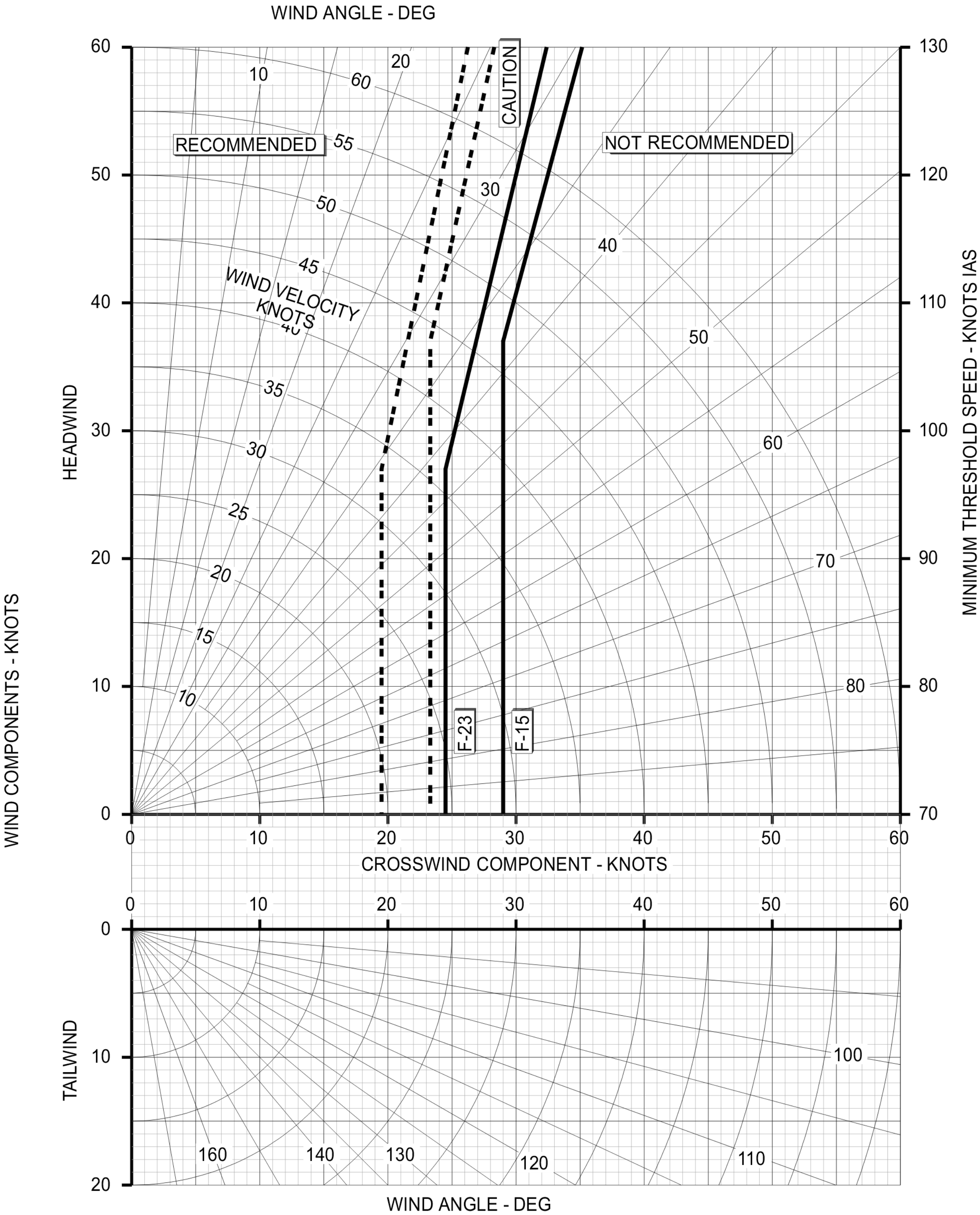

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Figure 8-1 Landing Crosswind Chart. Normal Landing

LANDING CROSSWIND CHART
SHORT FIELD LANDING

DATE: JUL. 2000
DATA BASIS: FLIGHT TEST
AIRCRAFT: C-295M
ENGINES: PW 127-G
PROPELLERS: HS 568F-5
FLAPS: LNDG (23º)

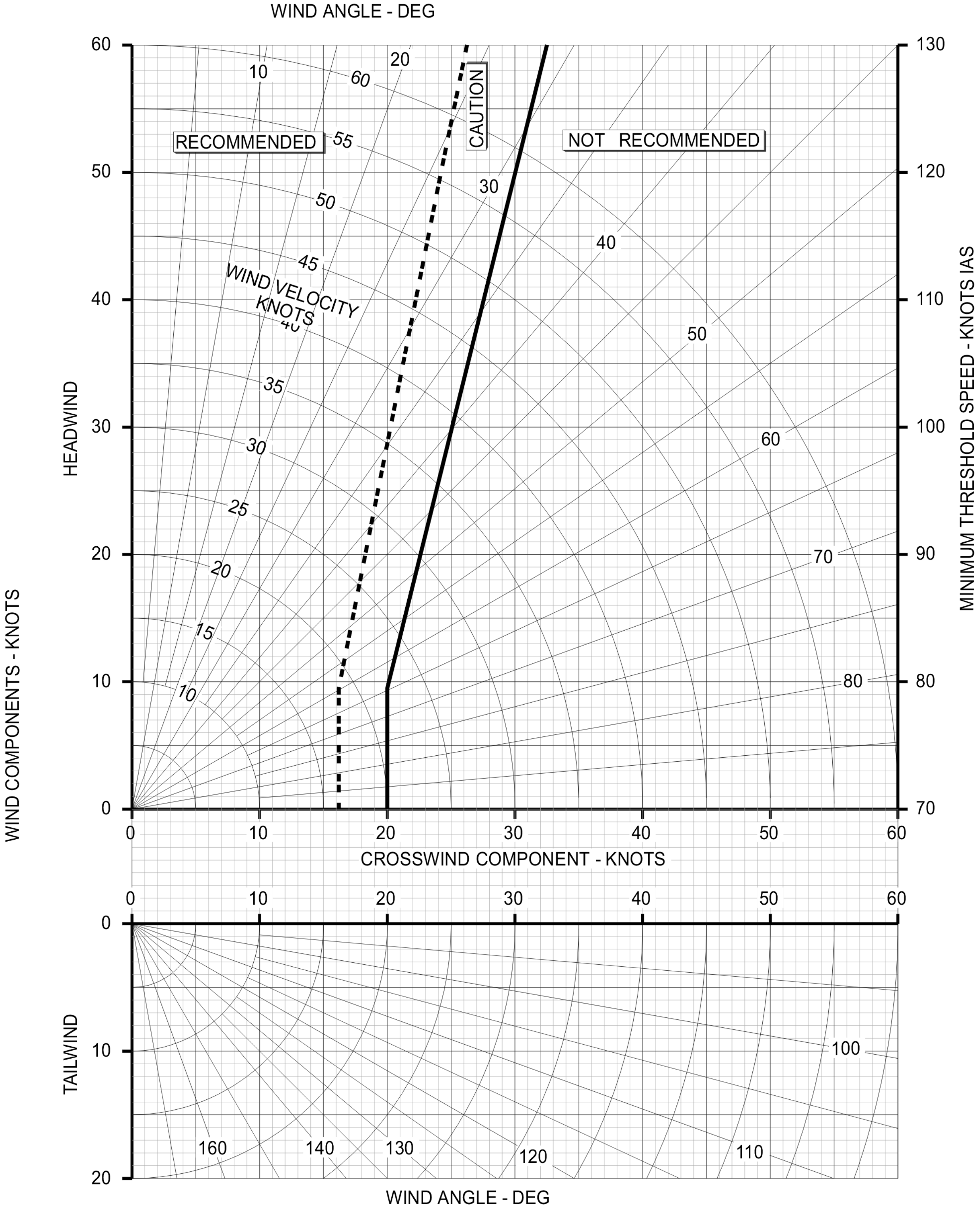

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Figure 8-2 Landing Crosswind Chart. Short Field Landing

AIR MINIMUM CONTROL SPEED

DATE:	JUL. 2000	**AIRCRAFT:**	C-295M	**FLAPS:**	APP (15º) and LNDG (23º)
DATA BASIS:	FLIGHT TEST	**ENGINES:**	PW 127-G		
		PROPELLERS:	HS 568F-5		

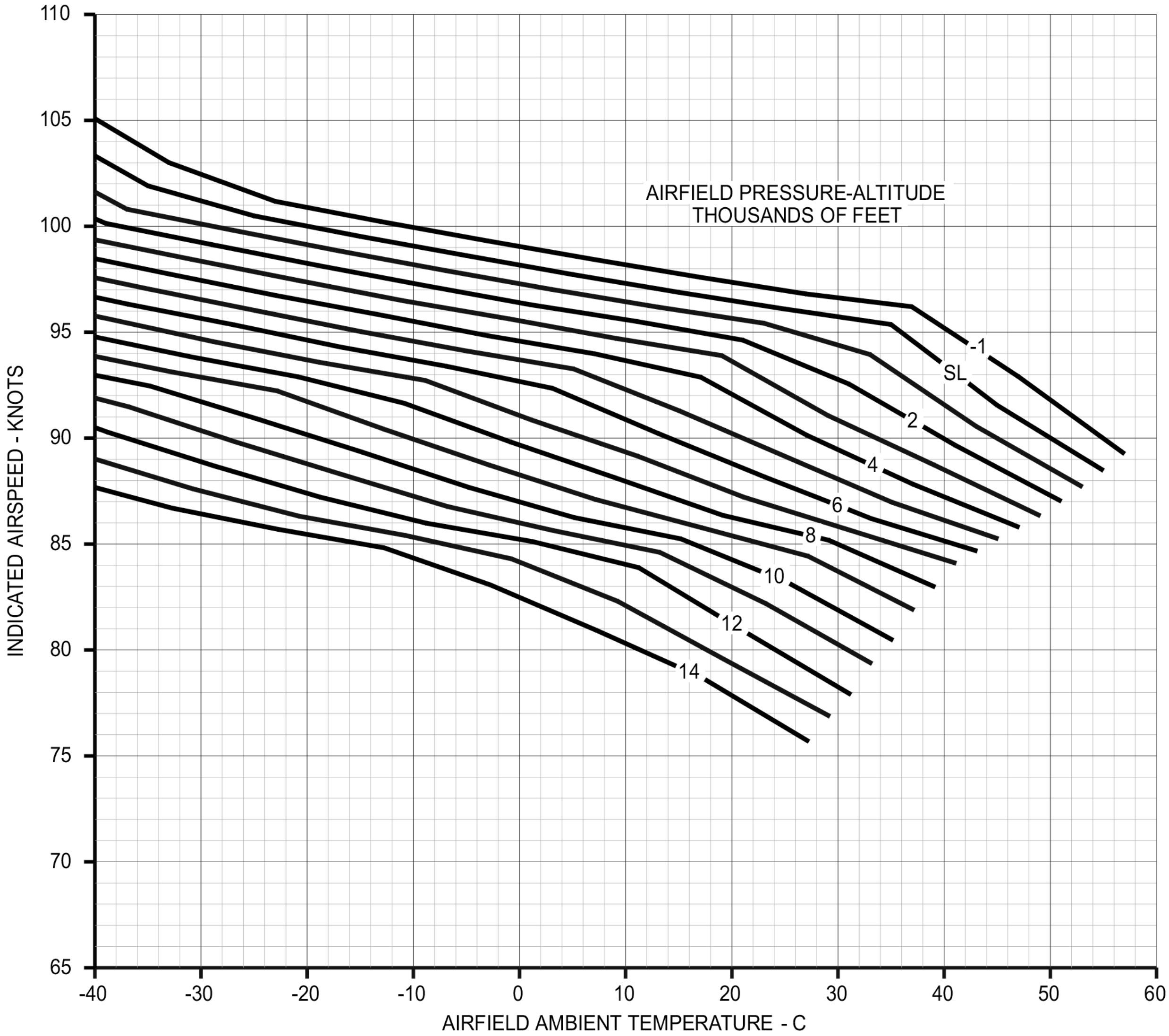

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Figure 8-3 Air Minimum Control Speed

LANDING SPEEDS
NORMAL LANDING

DATE:	JUL. 2000	**AIRCRAFT:**	C-295M	**FLAPS:**	LNDG (23º)
DATA BASIS:	FLIGHT TEST	**ENGINES:**	PW 127-G		
		PROPELLERS:	HS 568F-5		

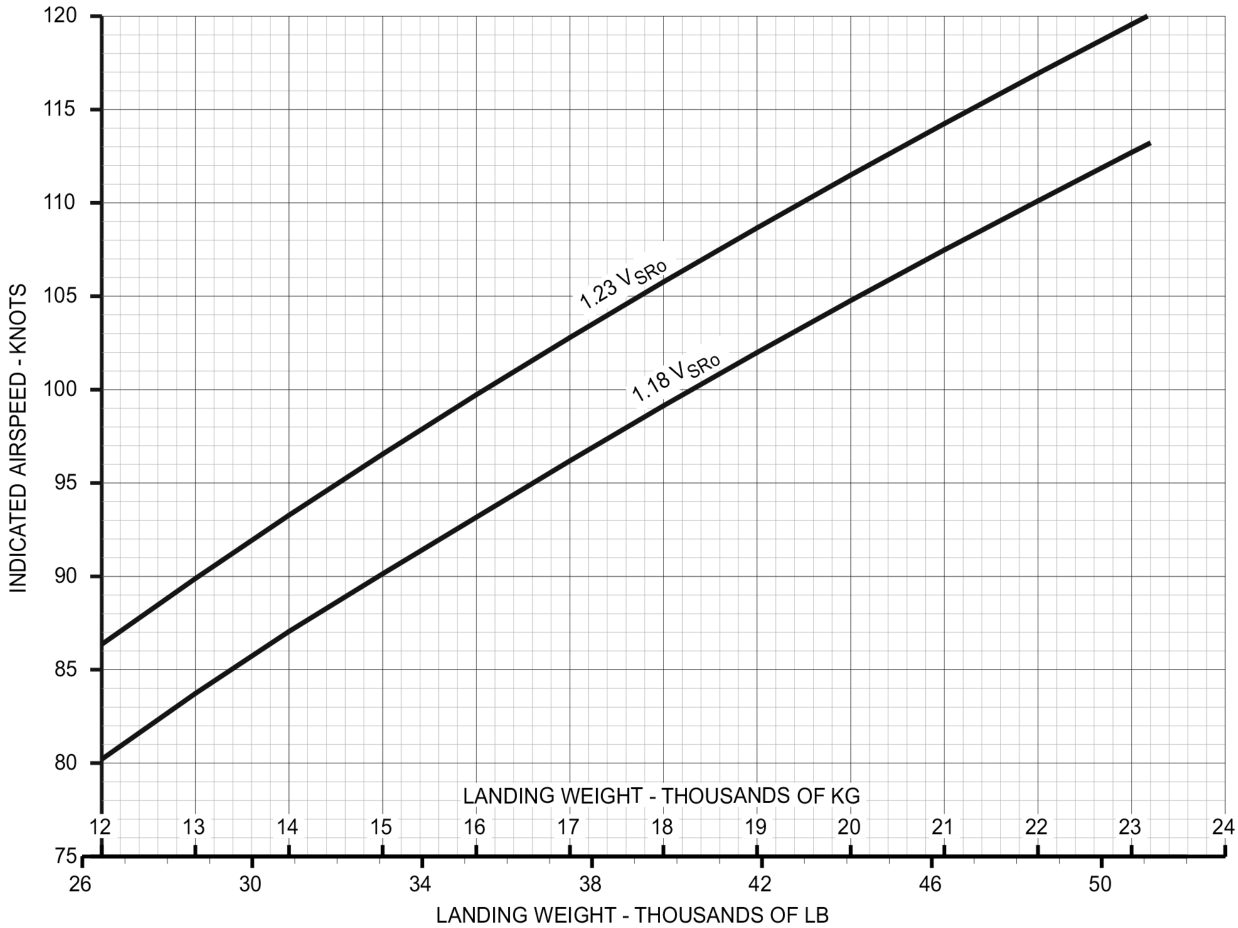

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Figure 8-4 Landing Speeds. Normal Landing

LANDING GROUND ROLL
NORMAL LANDING

DATE: JUL. 2000
DATA BASIS: FLIGHT TEST

AIRCRAFT: C-295M
ENGINES: PW 127-G
PROPELLERS: HS 568F-5

FLAPS: LNDG (23º)

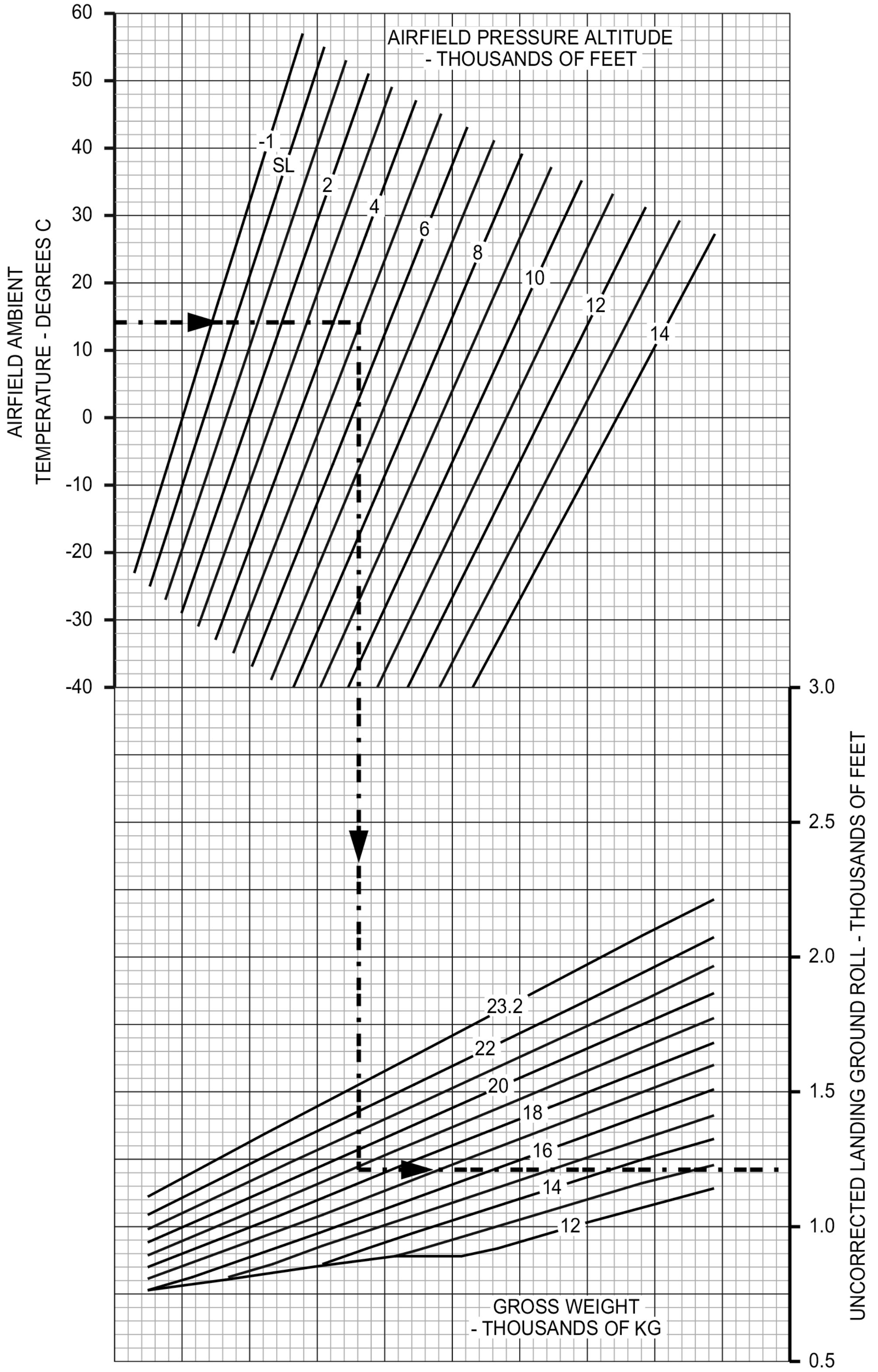

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Figure 8-5 (Sheet 1 of 2) Landing Ground Roll. Normal Landing

LANDING GROUND ROLL
NORMAL LANDING

DATE: JUL. 2000
DATA BASIS: FLIGHT TEST

AIRCRAFT: C-295M
ENGINES: PW 127-G
PROPELLERS: HS 568F-5

FLAPS: LNDG (23º)

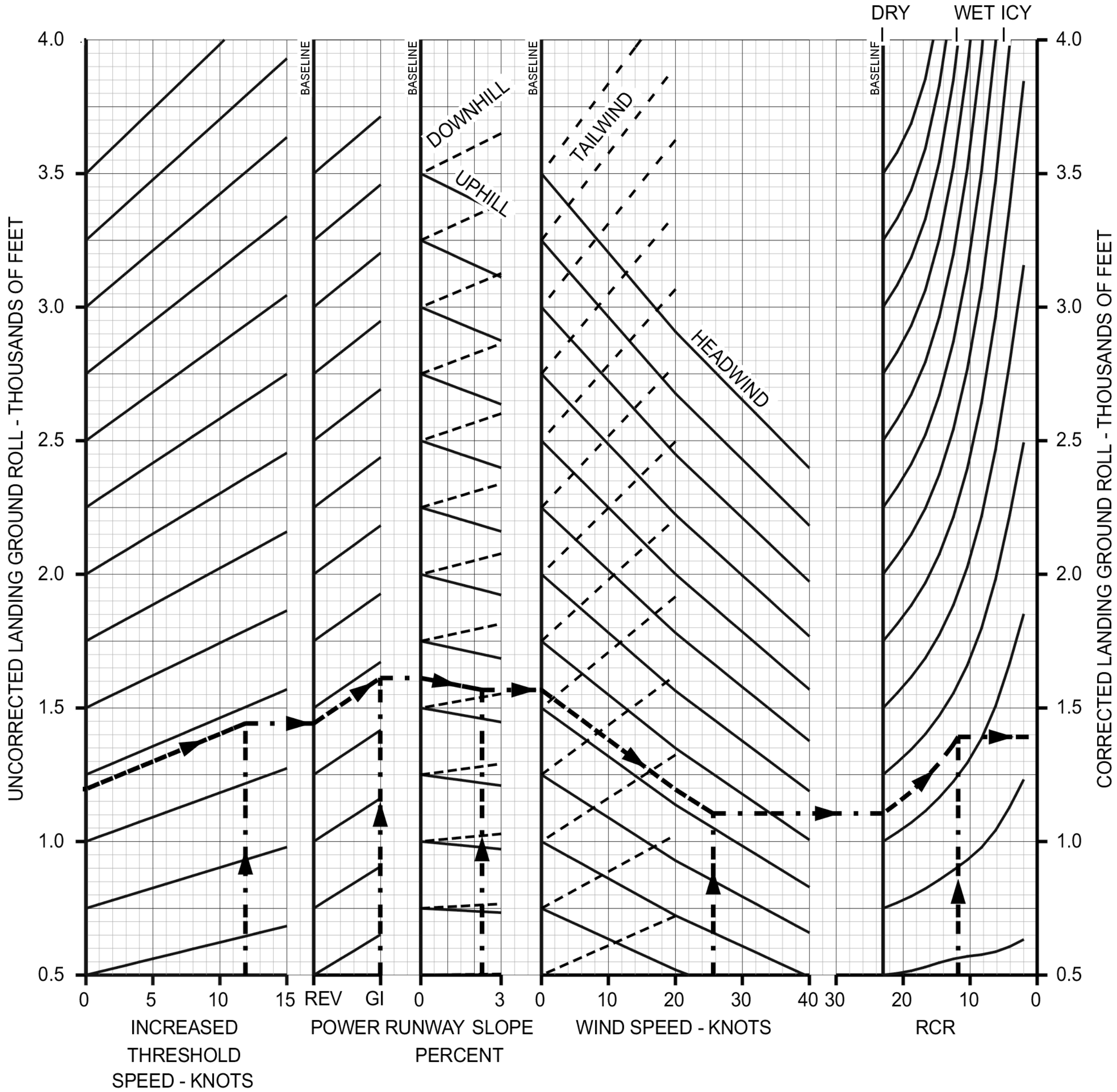

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Figure 8-5 (Sheet 2 of 2) Landing Ground Roll. Normal Landing

LANDING DISTANCE FROM 50 FT
NORMAL LANDING

DATE: JUL. 2000
DATA BASIS: FLIGHT TEST
AIRCRAFT: C-295M
ENGINES: PW 127-G
PROPELLERS: HS 568F-5
FLAPS: LNDG (23º)

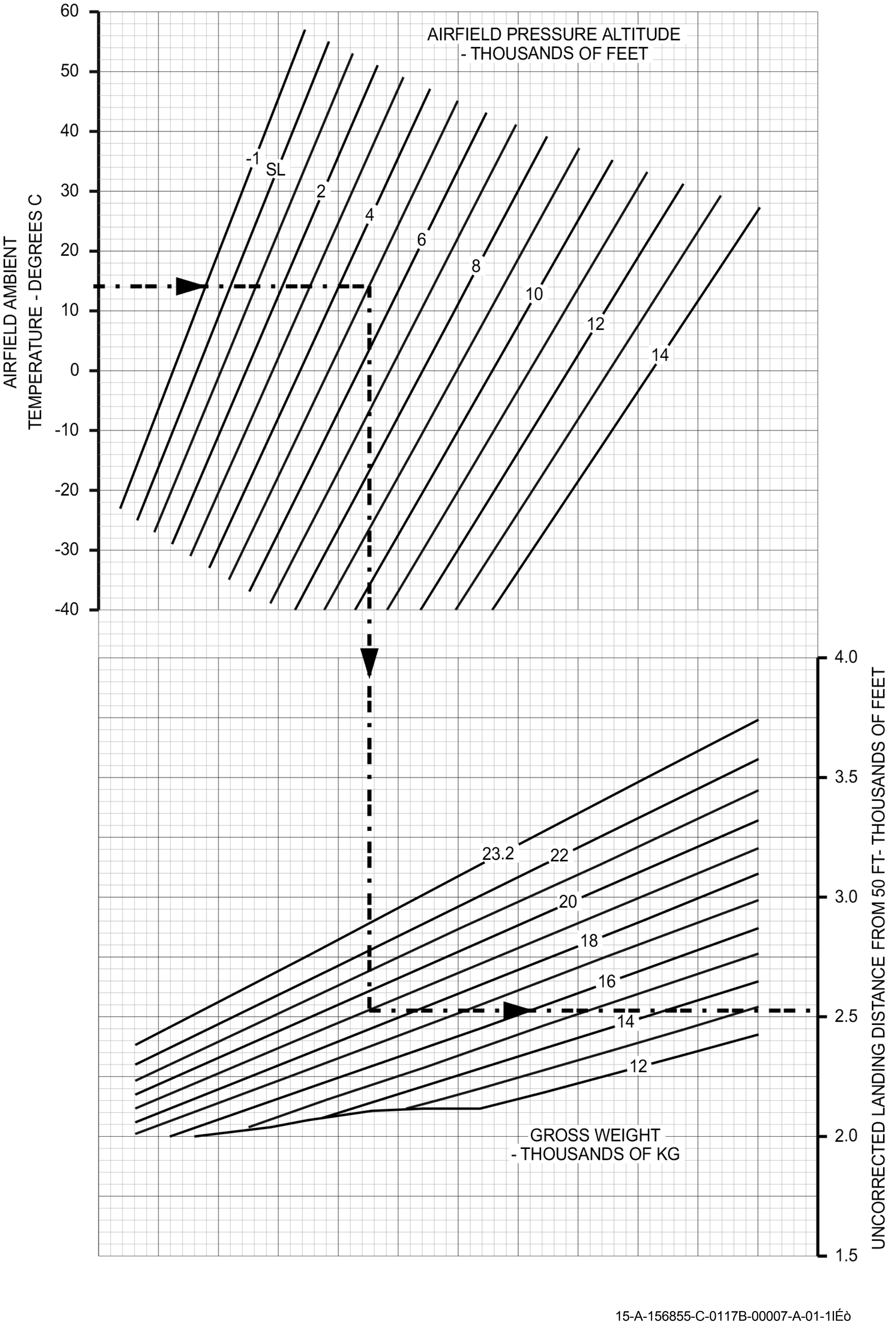

Figure 8-6 (Sheet 1 of 2) Landing Distance from 50 ft. Normal Landing

LANDING DISTANCE FROM 50 FT
NORMAL LANDING

DATE: JUL. 2000
DATA BASIS: FLIGHT TEST

AIRCRAFT: C-295M
ENGINES: PW 127-G
PROPELLERS: HS 568F-5

FLAPS: LNDG (23º)

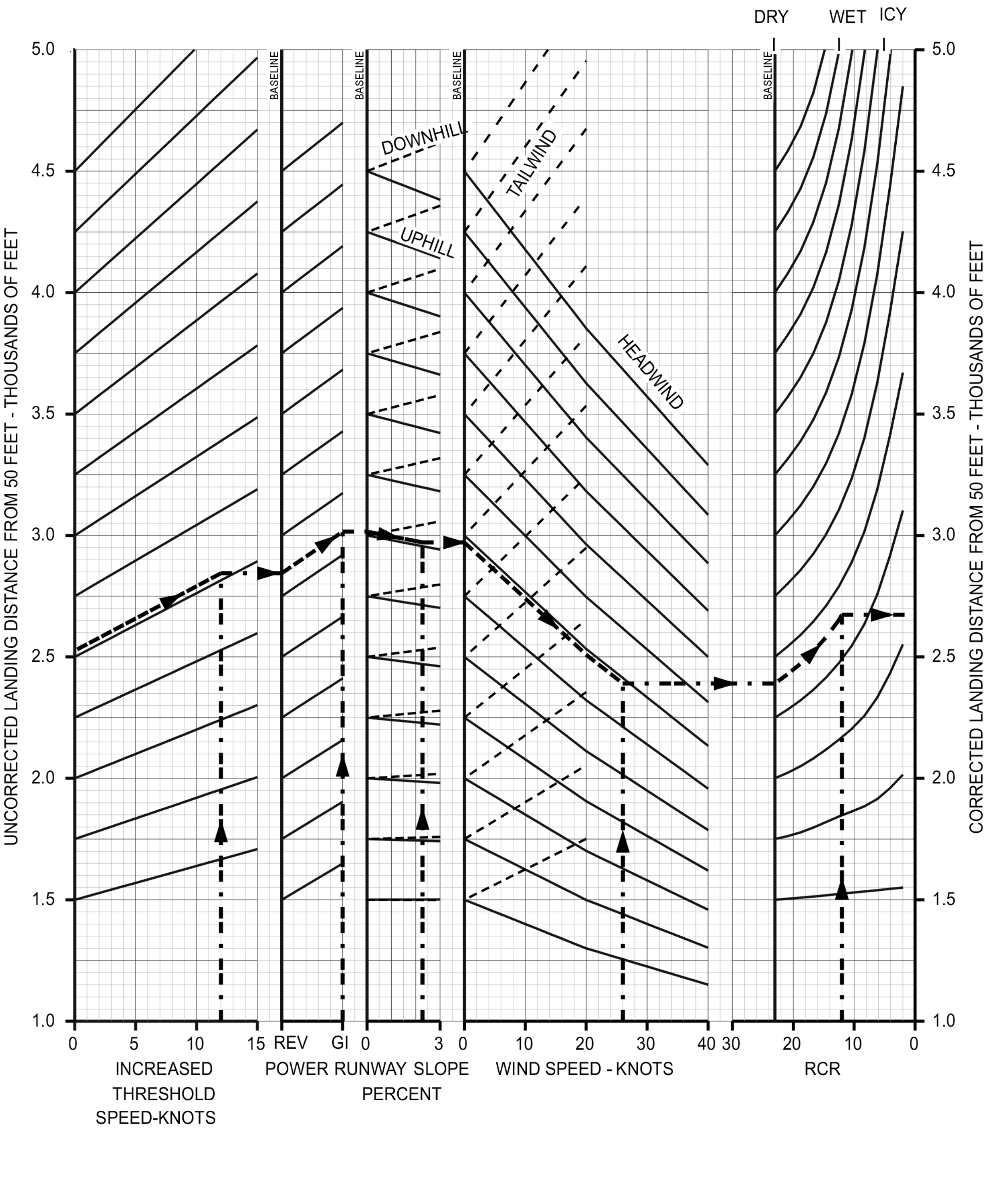

Figure 8-6 (Sheet 2 of 2) Landing Distance from 50 ft. Normal Landing

LANDING SPEEDS
SHORT FIELD LANDING

DATE:	JUL. 2000	**AIRCRAFT:**	C-295M	**FLAPS:**	LNDG (23º)
DATA BASIS:	FLIGHT TEST	**ENGINES:**	PW 127-G		
		PROPELLERS:	HS 568F-5		

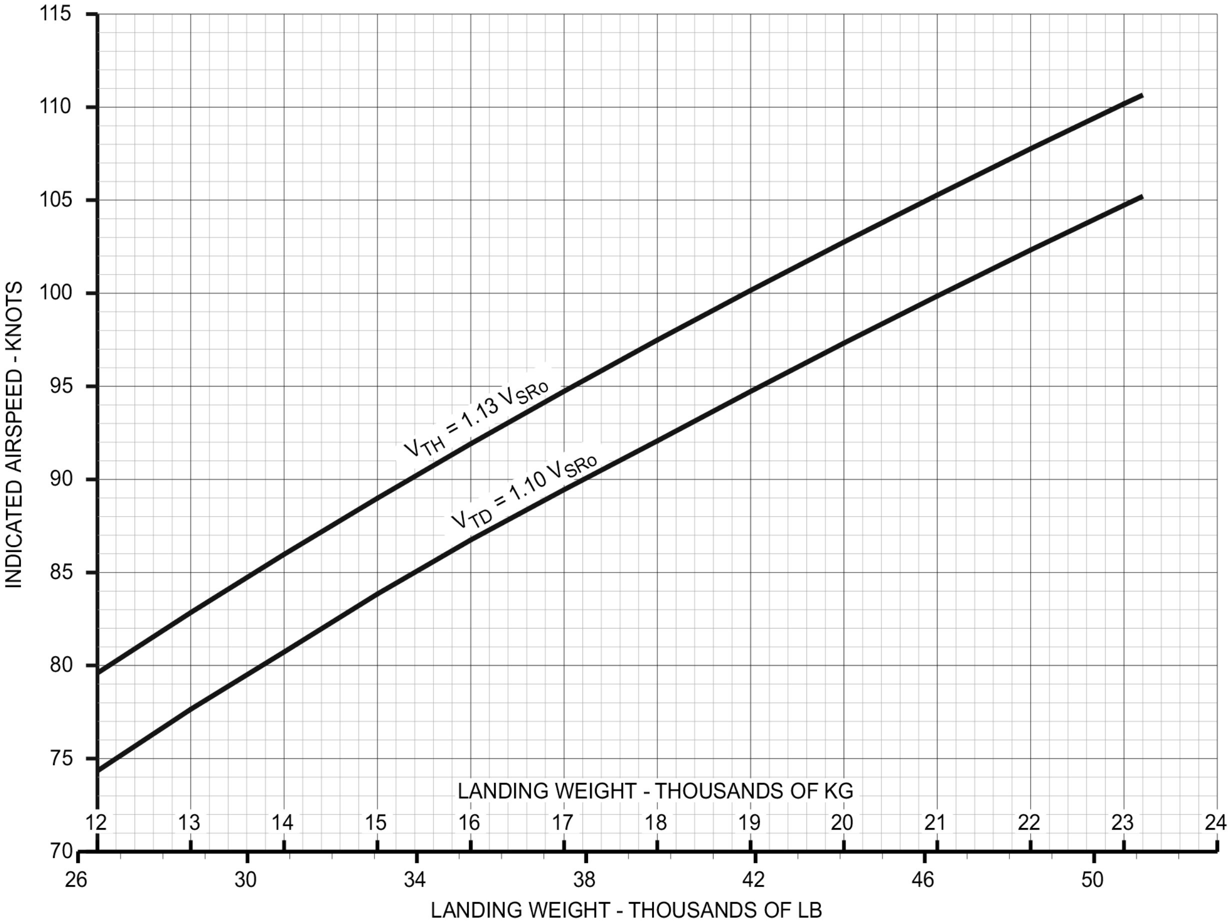

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Figure 8-7 Landing Speeds. Short Field Landing

LANDING GROUND ROLL
SHORT FIELD LANDING

DATE:	JUL. 2000	**AIRCRAFT:**	C-295M	**FLAPS:**	LNDG (23º)
DATA BASIS:	FLIGHT TEST	**ENGINES:**	PW 127-G		
		PROPELLERS:	HS 568F-5		

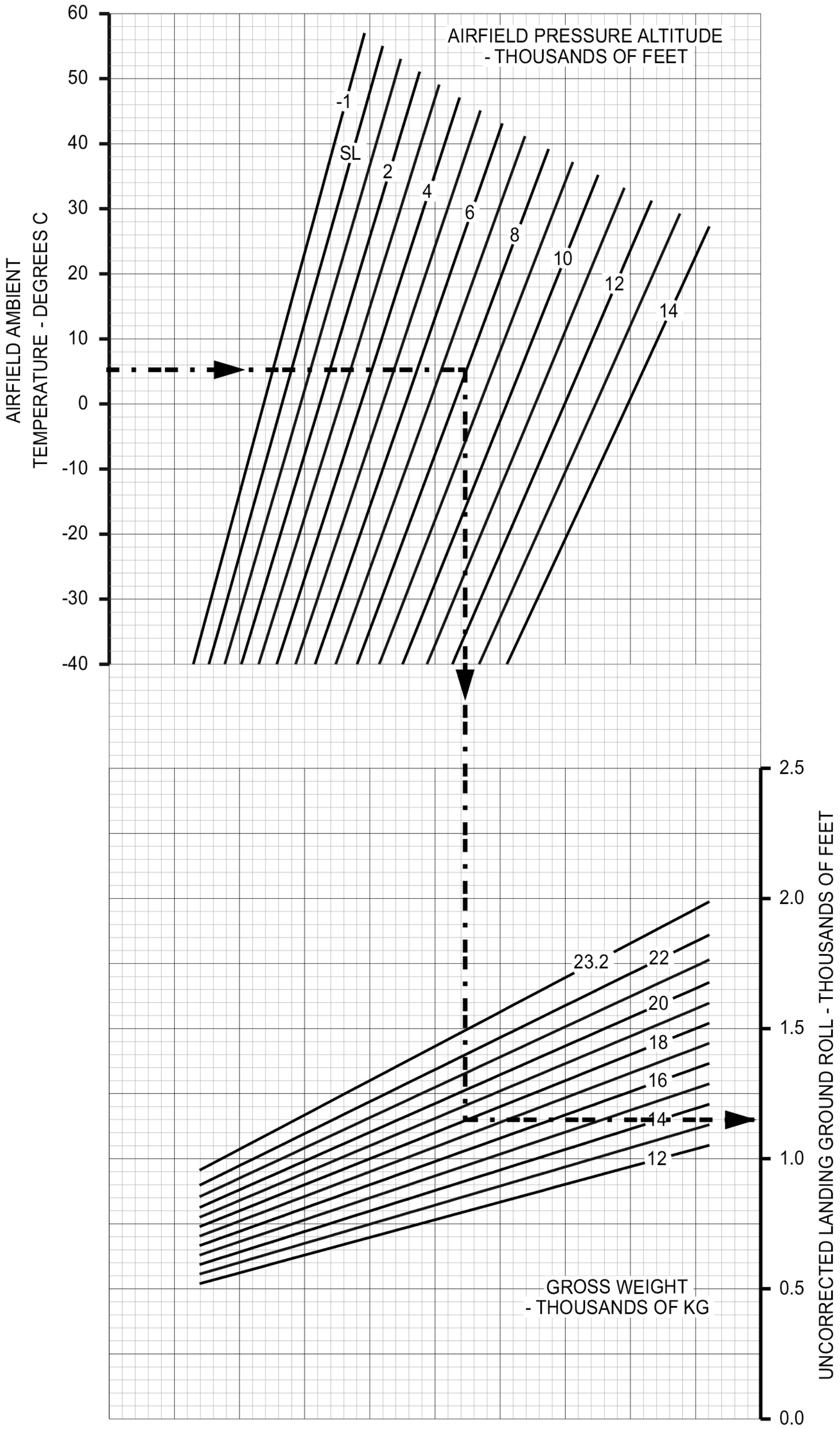

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Figure 8-8 (Sheet 1 of 2) Landing Ground Roll. Short Field Landing

LANDING GROUND ROLL
SHORT FIELD LANDING

DATE: JUL. 2000
DATA BASIS: FLIGHT TEST

AIRCRAFT: C-295M
ENGINES: PW 127-G
PROPELLERS: HS 568F-5

FLAPS: LNDG (23º)

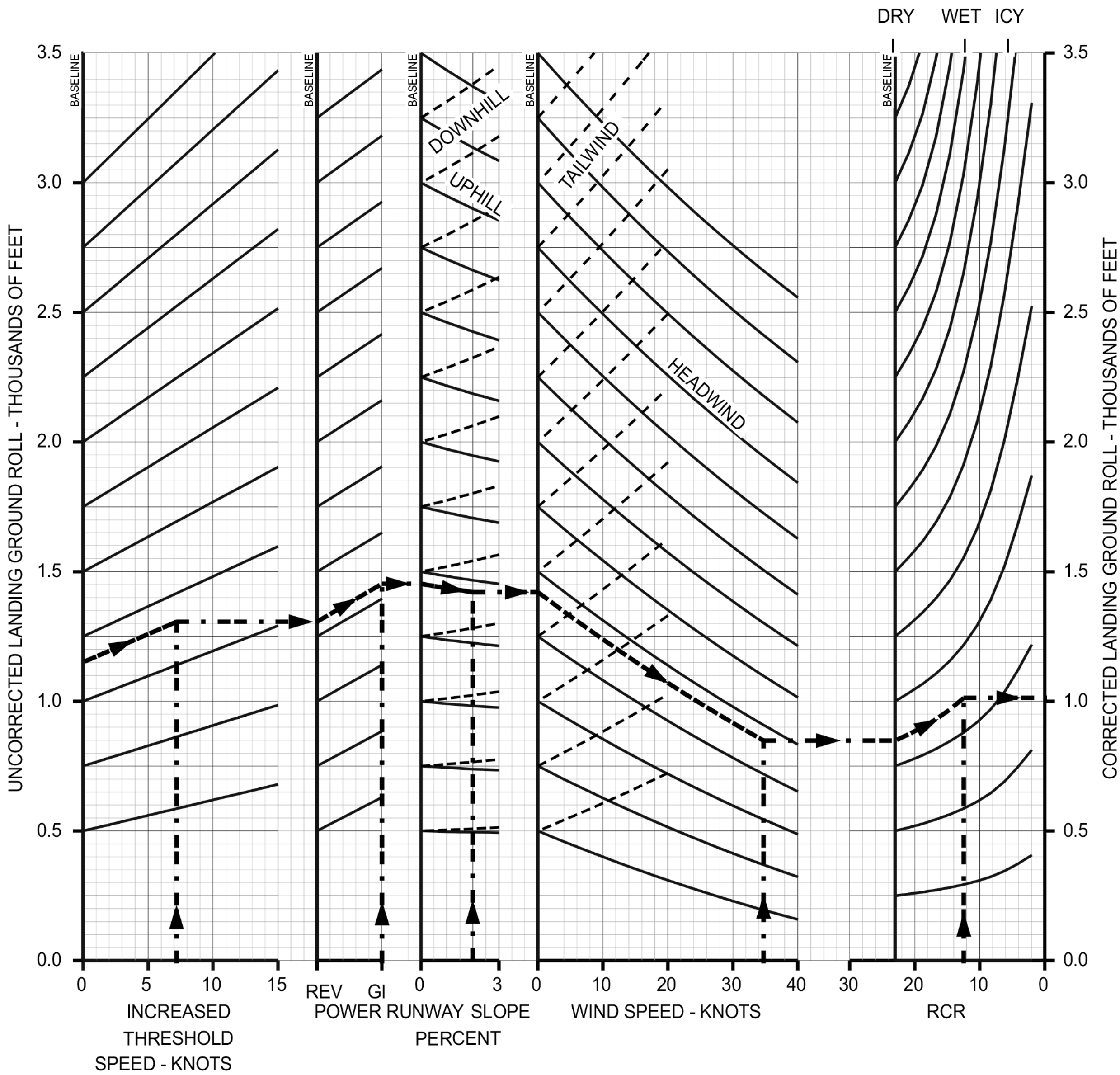

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Figure 8-8 (Sheet 2 of 2) Landing Ground Roll. Short Field Landing

LANDING DISTANCE FROM 50 FT
SHORT FIELD LANDING

DATE:	JUL. 2000	**AIRCRAFT:**	C-295M	**FLAPS:**	LNDG (23º)
DATA BASIS:	FLIGHT TEST	**ENGINES:**	PW 127-G		
		PROPELLERS:	HS 568F-5		

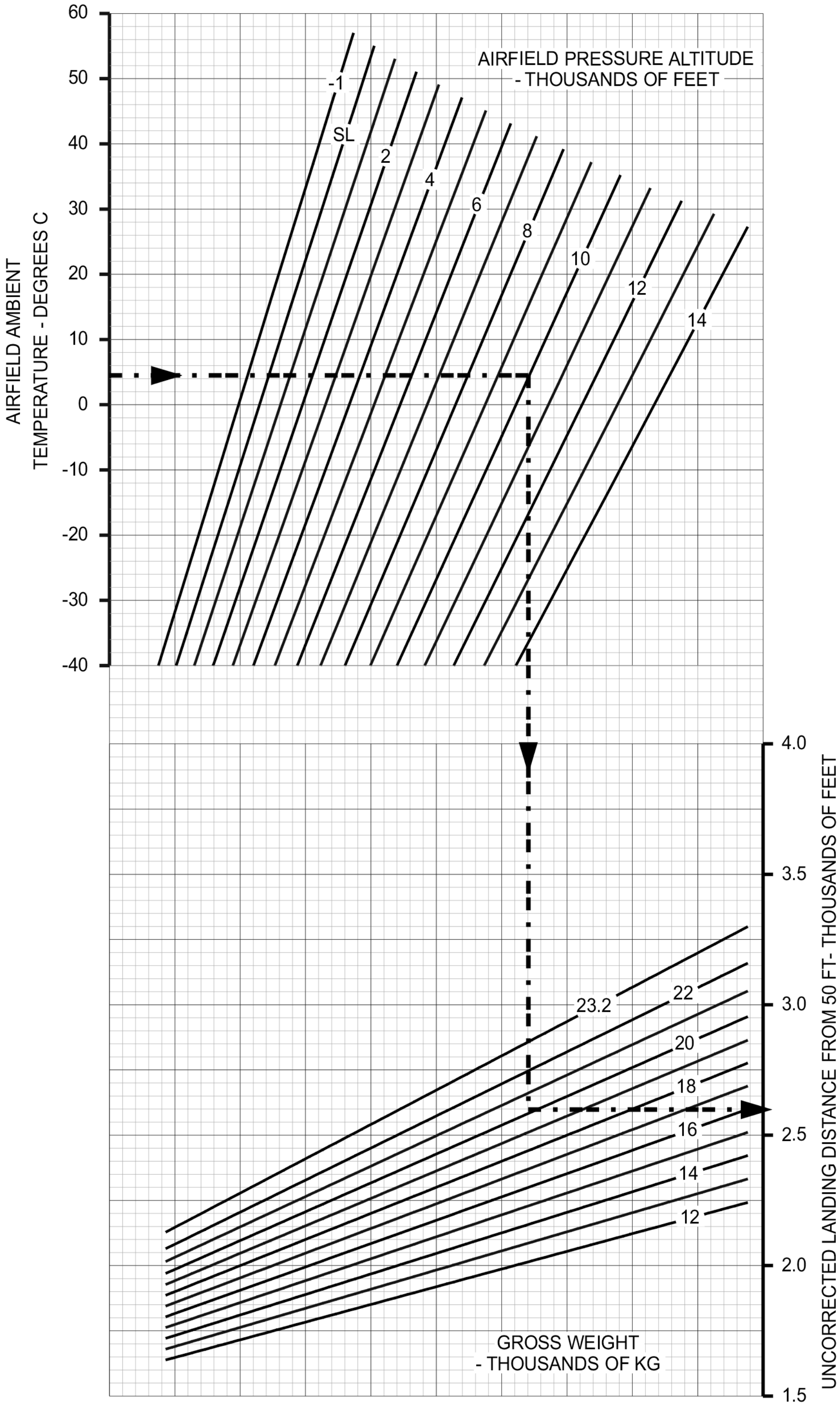

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Figure 8-9 (Sheet 1 of 2) Landing Distance from 50 ft. Short Field Landing

LANDING DISTANCE FROM 50 FT
SHORT FIELD LANDING

DATE: JUL. 2000
DATA BASIS: FLIGHT TEST
AIRCRAFT: C-295M
ENGINES: PW 127-G
PROPELLERS: HS 568F-5
FLAPS: LNDG (23º)

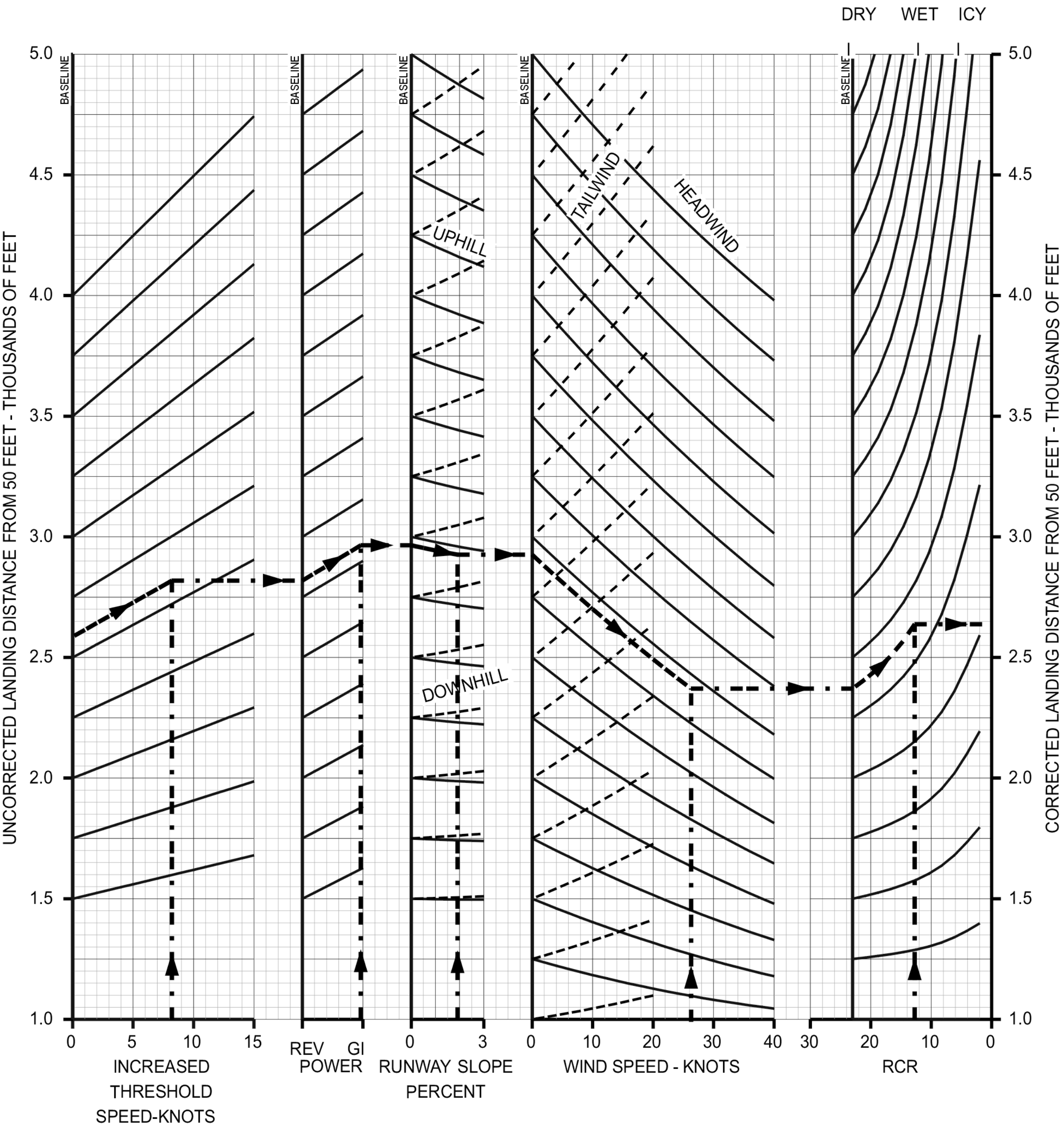

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Figure 8-9 (Sheet 2 of 2) Landing Distance from 50 ft. Short Field Landing

MAXIMUM BRAKE ENERGY

DATE: JUL. 2000
DATA BASIS: FLIGHT TEST

AIRCRAFT: C-295M
ENGINES: PW 127-G
PROPELLERS: HS 568F-5

FLAPS: APP (15º) and LNDG (23º)

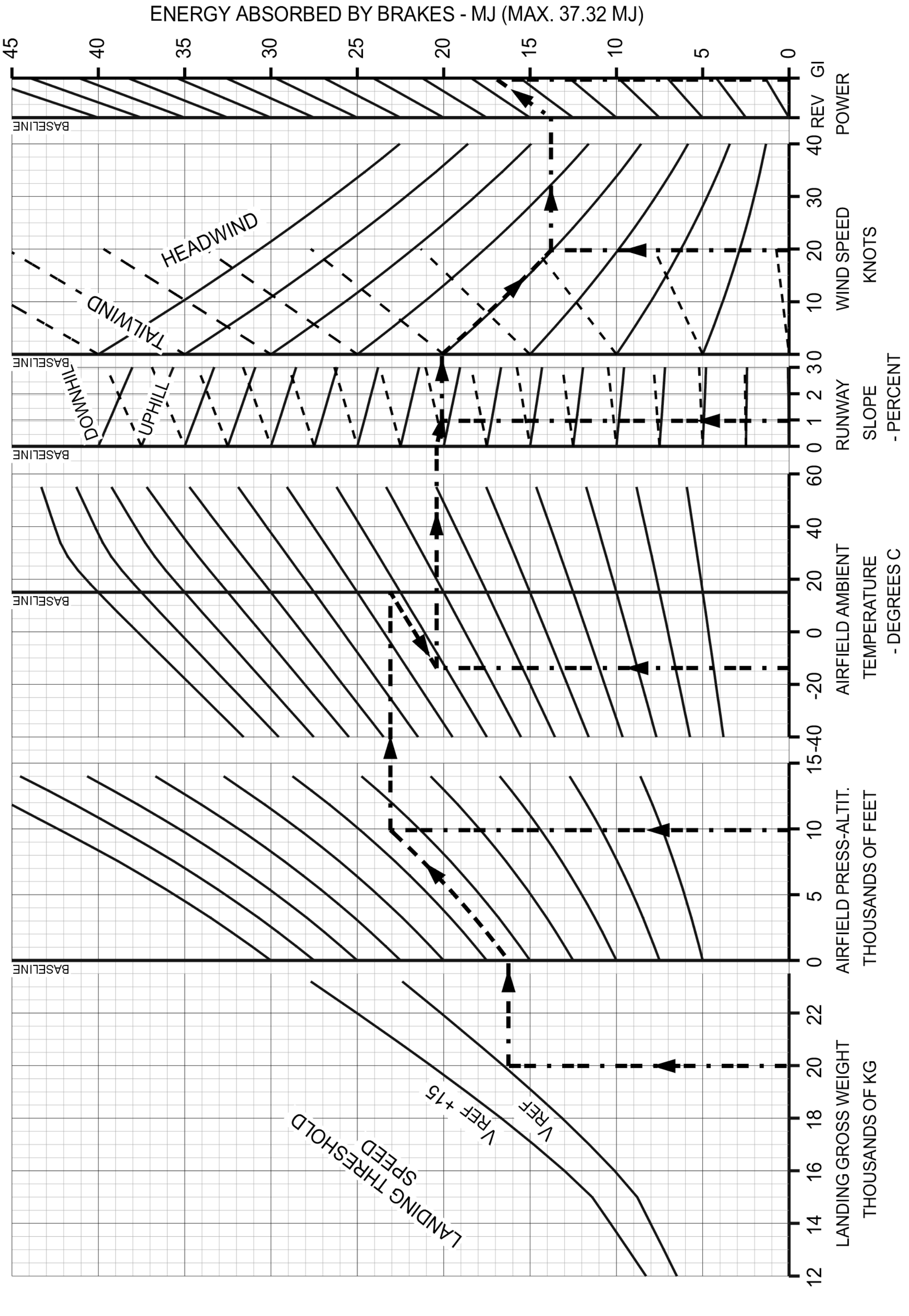

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Figure 8-10 Maximum Brake Energy

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