# CAD 385

# PERFORMANCE (TRANSPORT) GUIDANCE DOCUMENT

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**Civil Aviation Department**
**Hong Kong, China**

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**FOREWARD**

The information in this document is presented as a guide for those pilots preparing for the Performance (Transport) Examinations.

Materials contained in this document are in accordance with the Air Navigation (Hong Kong) Order 1995 (AN(HK)O), as amended, the Hong Kong Aviation Requirements (HKAR) and the Joint Aviation Requirements (JAR). Relevant information from the AN(HK)O and British Civil Airworthiness Requirements (BCAR) are included in Appendices 1 and 2 respectively for reference only. The text extracted from AN(HK)O, JAR and BCAR may have been abbreviated and amended to fit the particular presentation of this document and does not, therefore, purport to give precise interpretation. Where the full authoritative text is required, reference should be made to the appropriate documents.

The information given is correct at the time of issue of this document, but amendments to the AN(HK)O, HKAR and JAR may subsequently vary this information.

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**Contents**

Page

*Paragraph*

# 1. GENERAL

## 1.1 Aircraft General

### 1.1.1 Altitude vs Height

The altitude normally refers to the vertical distance between the lowest part of the aeroplane and the mean sea level.

The height is the vertical distance between the lowest part of the aeroplane and the relevant datum.

### 1.1.2 Relight Altitude

The maximum altitude for a safe and satisfactory engine restart.

### 1.1.3 Stabilising Altitude

The altitude where the aircraft climb gradient is not negative when the maximum available thrust is used.

### 1.1.4 Gross Performance vs Net Performance

The gross performance is the average performance which a fleet of aeroplanes should achieve if they are satisfactorily maintained and flown in accordance with the techniques described in the manual.

Net performance is the gross performance diminished to allow for various contingencies which cannot be accounted for operationally e.g., variations in piloting technique, tolerances in instrumentation, etc. It is improbable that the net performance will not be achieved in operation, provided the aeroplane is flown in accordance with the recommended techniques.

### 1.1.5 Indicated Airspeed, Calibrated Airspeed, True Airspeed

Indicated Airspeed (IAS) is the speed of an aircraft as shown on its pitot static airspeed indicator calibrated to reflect standard atmosphere adiabatic compressible flow at sea level uncorrected for airspeed system errors. Calibrated Airspeed (CAS) is the IAS corrected for the instrument calibration error and position error. True airspeed (TAS) is the airspeed of the aeroplane relative to the undisturbed air.

### 1.1.6 Engine Thrust Indicating Parameters

The parameter used for engine thrust setting. Either Engine Pressure Ratio (EPR) or low pressure compressor RPM (N1) is used for jet engine while torque or propeller RPM is normally used for turbo propeller engine.

## 1.2 Meteorological Data

1.2.1 International Standard Atmosphere

International Standard Atmosphere (ISA) means the atmosphere defined in ICAO Document 7488/2. The following is acceptable as ISA:

a. The air is a perfect dry gas;

b. The temperature at sea-level is +15 ℃;

c. The pressure at sea level is 1013.2 mb (29.92 in Hg)

d. The temperature gradient from sea-level to the altitude at which the temperature becomes -56.5 ℃ is 1.98 ℃ per 1000 ft;

e. The density at sea level under the above conditions is 1.225kg per $m^3$.

1.2.2 Outside/Static Air Temperature, Total Air Temperature

Outside Air Temperature (OAT) / Static Air Temperature (SAT) – the free air static (ambient) temperature

Total Air Temperature (TAT) – the static air temperature plus adiabatic compression (ram) rise as indicated on the Total Air Temperature indicator.

1.2.3 Pressure Altitude vs Density Altitude

Pressure altitude - the altitude in the ISA corresponding to a particular value of pressure.

Density altitude - the altitude in the ISA corresponding to a particular value of air density.

1.2.4 Wind

The actual wind velocity measured at a height of 10 metre above the runway surface. Wind component of not more than 50 % of the measured headwind or not less than 150% of tailwind should be used for take-off and landing performance calculations. These requirements may have been incorporated into the performance data, so that the actual measured and reported winds may be used without any further adjustment.

1.2.5 Runway State

Normal runway state is dry, but wet runway, wet ice, compacted snow, slush, standing water and loose snow performance information is prepared by the manufacturer as supplementary advisory information. A runway is considered as wet when it is well soaked but without significant areas of standing water. A runway is considered well soaked when there is sufficient moisture on the runway surface to cause it to appear reflective. For detailed definitions of other runway contaminants, paragraph 4.7.1 should be referred to.

1.2.6 Sources of Data

Terminal Aerodrome Forecast (TAF) and Meteorological Aviation Routine (METAR) are referred.

## 1.3 Aerodrome

1.3.1 Clearway

A clearway is an obstacle-free area beyond the take-off runway which can be used as a part of the take-off distance available.

1.3.2 Stopway

A stopway is an area beyond the take-off runway, no less wide than the runway and centred upon the extended centreline of the runway, able to support the aeroplane during a rejected take-off, without causing structural damage to the aeroplane, and designated by the airport authorities for use in decelerating the aeroplane during a rejected take-off.

1.3.3 Take Off Run Available (TORA)

Take-off run available is the length of runway which is declared available by the appropriate Authority and suitable for the ground run of an aeroplane taking off.

1.3.4 Take Off Distance Available (TODA)

Take-off distance available is either the distance from the starting point of TORA to the nearest obstacle in the direction of take-off projecting above the surface of the aerodrome and capable of affecting the safety of the aeroplane (which equals to the TORA plus the length of clearway), or 1.5 times the TORA, whichever is the less.

1.3.5 Accelerate-Stop Distance Available (ASDA)

Accelerate-stop distance available is the length of the take-off run available plus the length of stopway, if such stopway is declared available by the appropriate Authority and is capable of bearing the mass of the aeroplane under the prevailing operating conditions.

1.3.6 Slope

The slope of the runway refers to the runway surface profile and is normally expressed in terms of percentage uphill or downhill.

1.3.7 Landing Distance Available (LDA)

Landing distance available is the length of the runway which is declared available by the appropriate Authority and suitable for the ground run of an aeroplane landing.

1.3.8 Sources of Data

The Aerodromes Section of the Aeronautical Information Publication (AIP) shall provide the necessary data for an operator to comply with the weight and performance requirements of aeroplanes.

## 2. RULES AND REGULATIONS

The weight and performance specifications for aeroplanes engaged in public transport consist of two parts. They can be described as airworthiness requirements and operational requirements. The airworthiness requirements address the certification requirements of the aeroplane while the operational requirements set the rules to be followed by an aircraft operator.

### 2.1 Airworthiness Requirements

2.1.1 British Civil Airworthiness Requirements (BCAR)/
Federal Aviation Regulations (FAR)/
Joint Aviation Requirements (JAR)

Depending on time of design and the country of registration of the aeroplane, a particular airworthiness code is used. The major airworthiness codes in use are JAR, FAR and BCAR. Each of these codes consists of sections covering aircraft performance, structural and design requirements. For detailed performance requirements in the context of this document, the relevant regulations should be referred to.

2.1.2 Certificate of Airworthiness (C of A)

A C of A is issued after an aircraft is certified to be airworthy. The Aeroplane Flight Manual that forms part of the C of A contains limitations and performance data required to show compliance with the operational requirements.

2.1.3 Aeroplane Flight Manual (AFM) /
Flight Crew Operations Manuals (FCOM)

For day to day usage, data from the AFM may have been incorporated into the FCOM for use by flight crew and other operational personnel.

### 2.2 Operational Requirements

2.2.1 Air Navigation (Hong Kong) Order 1995, as amended (AN(HK)O)

The operational requirements of an aircraft are stipulated in the AN(HK)O. Articles 7 and 8 of AN(HK)O specify airworthiness requirements of the operator's aircraft. Article 29 of the AN(HK)O and the Air Navigation (General) Regulations (AN(G)R) contained in Schedule 15 of the AN(HK)O specify the operational rules in relation to aircraft performance considerations. The relevant sections from the AN(HK)O regarding performance group A are extracted and included in Appendix 1.

2.2.2 Air Operators' Certificates Requirements Document (AOCRD)

The AOCRD is issued by the Hong Kong Civil Aviation Department. It explains the process that must be followed in order to obtain an Air Operators' Certificate and indicates the requirements to be met by the operators in respect of equipment, organisation, staffing, training and other matters affecting the operations and maintenance of the aircraft.

## 2.3 Summary

An aircraft must have a C of A according to the relevant airworthiness code, e.g. JAR, FAR or BCAR. Furthermore, the aircraft must be operated in accordance with the requirements laid down in the AN(HK)O and, for public transport operators, the AOCRD.

## 3. SPEED DEFINITIONS

### 3.1 Take-off Speeds

3.1.1 Vef

Critical Engine Failure Speed, Vef – The calibrated airspeed at which the critical engine is assumed to fail.

3.1.2 V1

V1 is the Take-off Decision Speed scheduled in the AFM/FCOM. Initiation of rejected take-off procedure at or before V1 should result in a complete stop within the declared ASDA.

V1 may not be less than Vef plus the speed gained with the critical engine inoperative during the time interval between the instant at which the critical engine is failed, and the instant at which the pilot recognises and reacts to the engine failure, as indicated by the pilot's application of the first retarding means during rejected take-off (or during accelerate-stop tests).

3.1.3 Vmu

Minimum Unstick Speed, Vmu – The calibrated airspeed at and above which the aeroplane can safely lift off the ground, and continue the take-off.

3.1.4 Vr

Rotation Speed, Vr – The speed at which the pilot initiates action to raise the nose gear off the ground, during the acceleration to V2.

3.1.5 V2

Take-off Safety Speed, V2 – The target speed to be attained at the 35 foot height, assuming recognition of an engine failure at or after V1.

3.1.6 V4

The Steady Initial Climb Speed V4 - The all engines operating take-off climb speed (e.g. V2 + 10 kts) used to the point where acceleration to flap retraction speed is initiated. V4 should be attained by a height of 400 feet.

3.1.7 Vmcg

The Minimum Control Speed on the Ground, is the calibrated airspeed during the take-off run, at which, when the critical engine is suddenly made inoperative (with the remaining engine(s) at take-off thrust) and with its propeller, if applicable, in the position it automatically achieves, it is possible to maintain control of the aeroplane with the use of the primary aerodynamic controls alone (without the use of nose-wheel steering) to enable the take-off to be safely continued using normal piloting skill.

3.1.8 Vmc (as defined in JAR) / Vmca (as defined in BCAR)

Minimum Control Speed, Vmc / Vmca – The calibrated speed, at which, when the critical engine is suddenly made inoperative with the remaining engine(s) at take-off thrust, it is possible to maintain control of the aeroplane with that engine still inoperative, and maintain straight flight with an angle of bank of not more than 5 °.

3.1.9 Vmcl

Minimum Control Speed for Landing, Vmcl – The minimum control speed with the aeroplane configured for approach at which the aeroplane is controllable with a maximum of 5 ° bank when the critical engine suddenly becomes inoperative with the remaining engine(s) at take-off thrust.

3.1.10 Vmbe

Maximum Brake Energy Speed, Vmbe – The speed from which the aeroplane may be brought to a stop without exceeding the maximum energy absorption capability of the brakes.

3.1.11 Vs1g

The One-g Stall Speed, Vs1g - The minimum calibrated airspeed at which the aeroplane can develop a lift force (normal to the flight path) equal to its weight, whilst at an angle of attack not greater than that at which the stall is identified.

3.1.12 Vs

Stall Speed, Vs – The stall speed is the minimum calibrated airspeed obtained when the aeroplane is stalled. JAR imposes additional conditions for defining Vs such as not less than 94% of the Vs1g. For detailed reference, the relevant sections in JAR should be referred to.

3.1.13 Vlof

Vlof is the calibrated airspeed at which the aeroplane first becomes airborne.

## 3.2 Approach and Landing Speeds

3.2.1 Vref

Reference Speed, Vref – It normally refers to the minimum speed at the 50 foot height in a normal landing at a particular landing flap configuration.

## 3.3 Take-off Speeds Relationship

V1 must not be less than Vmcg or greater than the Vr or Vmbe. In order to satisfy JAR, Vr must be equal to or greater than 1.05 Vmca and V1. Depending on the aircraft type, V2 should not be less than 1.15 or 1.2 times Vs. Furthermore, V2 should not be less than 1.13 times Vs1g in the take-off configuration.

### 3.4 Landing Speeds Relationship

Vref should normally be at least 1.3 times the Vs or 1.23 times the Vs1g in the landing configuration.

# 4. TAKE-OFF PERFORMANCE

## 4.1 Introduction

In order to provide a satisfactory safety level, it is necessary to ensure that the aeroplane performance, under all engines operating and assumed engine failure conditions at stipulated meteorological conditions, will be adequate at the proposed take-off weight. In other words, the relevant take-off distance required, take-off run required and accelerate-stop distance required do not exceed the take-off distance available, take-off run available and accelerate-stop distance available respectively.

Limitations on take-off gross weight can be divided into the following basic categories: Field Length Limited, Vmcg Limited, Brake Energy Limited, Tire Speed Limited, Climb Limited and Obstacle Limited. Climb Limited weight and Obstacle Limited take-off weight also affect the climb performance of the aeroplane and are covered in the next chapter.

## 4.2 Field Length Limited Take-off Weight

The take-off weight is field length limited when the runway length required by the airworthiness requirements is equal to the runway length available.

### 4.2.1 Take Off Run Required (TORR)

*Dry runway :*

TORR on dry runway is the greater of :

- the distance to take-off and climb to a point equidistant between a point at which Vlof is reached and the 35 foot height point with a failure of the critical engine at Vef,
- 115% of the distance to take-off and climb to a point equidistant between the point at which Vlof is reached and the 35 foot height point with all engines operating.

*Wet runway :*

TORR on wet runway is the greater of :

- the distance to take-off and climb to a point at which Vlof is reached with a failure of the critical engine at Vef,
- 115% of the distance to take-off and climb to a point equidistant between the point at which Vlof is reached and the 35 foot height point with all engines operating.

4.2.2 Take Off Distance Required (TODR)

*Dry runway :*

TODR on dry runway is the greater of :

- the distance to take-off and climb to a height of 35 feet with a failure of the critical engine at Vef, or
- 115% of the distance to take-off and climb to a height of 35 feet with all engines operating.

*Wet runway :*

TODR on wet runway is the greater of :

- the distance to take-off and climb to a height of 15 feet in a manner consistent with the achievement of V2 before reaching 35 feet above the take-off surface, with a failure of the critical engine at Vef, or
- 115% of the distance to take-off and climb to a height of 35 feet with all engines operating.

4.2.3 Accelerate-Stop Distance Required (ASDR)

*Dry runway :*

ASDR is the sum of the distances required to :

- accelerate with all engines operating, and
- come to a complete stop assuming initiation of the rejected take-off at V1.

*Wet Runway :*

ASDR is the same as dry runway requirement except with a wet runway V1 speed.

*4.2.3.3 Configurations Used in the Certification*

In the transition portion of the Rejected Take-Off (RTO), the aeroplane's configuration is changed from the "GO" to the "STOP" mode. This includes applying maximum braking, retarding the throttles and raising the speedbrakes. The transition phase demonstrated in flight test is artificially expanded for the purpose of calculating the certified take-off distances presented in the AFM. This expansion is not meant to allow extra time for making "NO-GO" decision but to allow sufficient time or distance for "the average pilot" to configure the aeroplane to the stopping mode.

On dry runway the accelerate-stop distance is normally based on manual braking and manual spoilers. The effect of reverse thrust is not included in the JAR dry runway accelerate-stop distance calculation but should be used in operational service.

On wet or contaminated runway, performance credit for reverse thrust, if installed and certified, is assumed.

4.2.4 Balanced Field Length

The relationship between TODA and ASDA depends on take-off decision speed, V1. When the engine failure recognition speed is chosen so that these distances are equal, this is a balanced field length.

4.2.5 Relationship between Runway Length Requirement and V1

For a given weight, a lower V1 requires a longer TODR. Conversely, a higher V1 results in a shorter TODR.

For a given weight, a lower V1 results in a shorter ASDR, while a higher V1 requires a longer ASDR.

## 4.3 Vmcg Limited Take-off Weight

In order to keep the aeroplane controllable when a critical engine fails before V1 during the take-off roll, V1 must not be less than Vmcg. When the selected V1 is less than Vmcg, this V1 must be increased to the value of Vmcg. However, by doing so the ASDR may rise to a figure that exceeds the ASDA. Therefore the take-off weight has to be further reduced in order to keep the ASDR within the runway available. This reduced weight is the Vmcg limited weight.

A runway with long ASDA is less vulnerable to Vmcg limit because V1 may be increased without making ASDR higher than ASDA.

## 4.4 Brake Energy Limited Take-off Weight

V1 must not exceed the Vmbe otherwise the aircraft cannot be stopped within the ASDA in case of engine failure during take-off. When V1 exceeds the Vmbe, take-off weight must be reduced so that V1 is within the Vmbe limit. This reduced weight is the Vmbe limit weight.

## 4.5 Tyre Speed Limited Take-off Weight

The tyres may burst if the liftoff speed exceeds the true ground speed limitation on the tyres. Therefore the take-off weight must be reduced to keep the liftoff speed within the ground speed limits. This reduced weight is the tyre speed limit weight.

## 4.6 Variables Affecting Field Length Limited Performance

4.6.1 Temperature

When ambient temperature goes up, take-off thrust diminishes and the regulated take-off weight decreases.

4.6.2 Pressure Altitude

Low pressure altitude results in an increase in air density, mass flow rate and a lower true airspeed than at high pressure altitude. Hence, the regulated take-off weight increases with a decrease in pressure altitude.

4.6.3 Wind

Headwind shortens the acceleration distance and the stopping distance which results in a better regulated take-off weight.
Tailwind increases the acceleration distance and also the stopping distance which results in a lower regulated take-off weight.

4.6.4 Runway Slope

A runway with an uphill slope results in a longer acceleration distance and hence a lower regulated take-off weight. On the other hand, a downhill slope translates to an increased acceleration and a shorter acceleration distance which results in an increase in the regulated take-off weight.

4.6.5 Flaps Setting

Larger flap setting results in a shorter take-off distance required.

4.6.6 Air-conditioning Packs On/Off

Bleed air for air-conditioning is normally tapped from the running engines. Take off with air-conditioning packs off will result in more thrust provided for accelerating the aircraft, hence higher regulated take-off weight is available.

4.6.7 Thrust

Higher take-off thrust normally results in a higher regulated take-off weight. However, when the take-off weight is Vmcg limited, the higher the power of the engine, the stronger the turning moment will result after an engine fails. Therefore a higher Vmcg speed is required for the rudder to generate a moment to counter balance the turning force. This increase in the Vmcg speed will impose a reduction in the Vmcg limited weight.

4.6.9 Braking Forces

When braking force is reduced due to either take-off on a contaminated runway or the aircraft is dispatched with unserviceable equipment which affects the stopping capability of the aircraft, V1 has to be reduced to cater for the increase in stopping distance. Under these circumstances the regulated take-off weight may be limited by Vmcg.

## 4.7 Contaminated Runway Take-off Performance

### 4.7.1 Definition of Contaminants

Standing water, slush or loose snow covered runway - More than 25 percent of the runway surface area (whether in isolated areas or not) within the required length and width being used is covered by surface water more than 3 mm deep or by slush or loose snow equivalent to more than 3 mm of water.

Compacted snow covered runway - Runway covered with snow which has been compressed into a solid mass and resists further compression and will hold together or break into lumps if picked up.

Wet ice covered runway – A runway surface condition where braking action is expected to be very low, due to the presence of wet ice.

The level of safety is decreased when operating on contaminated runways and therefore every effort should be made to ensure that the runway surface is cleared of any significant precipitation.

The performance information assumes any standing water, slush or loose snow to be of uniform depth and density.

The provision of performance information for contaminated runways does not imply that ground handling characteristics on these surfaces will be as good as can be achieved on dry or wet runways, particularly in crosswinds and when using reverse thrust.

### 4.7.2 Take-off Performance Requirements on Contaminated Runway

The contaminated runway take-off performance (includes the take-off run required, take-off distance required and accelerate-stop distance required) appropriate to the relevant contaminant is derived in accordance with those requirements for a wet runway but with different braking coefficients.

### 4.7.3 Obstacle Limited Weight on Contaminated Runway

Reduction in obstacle limited weight may be required because the obstacle distance which is measured from the 35 feet reference zero point, is shortened under contaminated runway.

# 5. CLIMB PERFORMANCE

## 5.1 Introduction

Climb performance of an aeroplane can be divided into two categories: Obstacle Limited and Climb Limited.

## 5.2 Obstacle Limited Take-off Weight

The take-off gross weight becomes obstacle limited when the net take-off flight path just clears an obstacle by the required margin (see 5.2.5). The critical engine is assumed inoperative.

### 5.2.1 Take-off Flight Path

The take-off path assumes failure of the most critical engine at Vef and begins at 35 feet above the take-off surface at the end of the TODR and extends to a point where the aeroplane is at least 1500ft above the take-off surface and has achieved the enroute configuration. Final climb speed should be reached at the end of the take-off flight path.

The take-off path is divided into segments representing distinct changes in aeroplane configuration, airspeed, and engine thrust as defined below.

#### *5.2.1.1 First Segment*

The first segment starts from the end of TODR to the point where the landing gear is assumed to be fully retracted, using take-off thrust and take-off flaps at a constant V2 speed.

#### *5.2.1.2 Second Segment*

The second segment begins from gear up point to a gross height of at least 400 feet, using take-off thrust and take-off flaps at a constant V2 speed.

#### *5.2.1.3 Third Segment*

The third segment is a horizontal distance required to accelerate, at constant altitude using take-off thrust, to the final climb speed while retracting flaps in accordance with the recommended speed schedule.

#### *5.2.1.4 Final Segment*

The final segment extends from the end of third segment to a gross height of at least 1500 feet with flaps up, maximum continuous thrust and at final climb speed.

### 5.2.2 Maximum Level Off Height

It is the maximum height at which the third segment can be completed before the time limit on the use of take-off thrust expires. The use of take-off thrust is normally time-limited to 5 minutes and may be extended to 10 minutes if additional certification is obtained. This extension to 10 minutes is normally limited to the situation where an engine failure actually occurs and there is an obstacle in the take-off flight path. The use of 10 minutes simplifies the flight path determination for high, distant obstacles. Maximum Level Off Height is improved when 10 minutes take-off thrust is used.

5.2.3 Gross Gradient vs Net Gradient

Climb gradient is the ratio, expressed as a percentage, of the change in geometric height divided by the horizontal distance travelled in a given time. Gross gradient is the average performance of the aeroplane under specified conditions, while net gradient is the gross gradient reduced by a certain percentage for certification purpose. The following table shows the gradient reduction required by the JAR.

| | Gradient Reduction |
|---|---|
| Two-engined aeroplane | 0.8% |
| Three-engined aeroplane | 0.9% |
| Four-engined aeroplane | 1.0% |

5.2.4 Gross Height vs Net Height

Gross height is the geometric height attained at any point in the take-off flight path using gross climb performance. Gross height is used for calculating the pressure altitude for the purpose of obstacle clearance, and the height at which wing flap retraction is initiated.

Net height is the geometric height attained at any point in the take-off flight path using net climb performance. It is used to determine the net flight path which must clear any obstacle by at least 35 feet to comply with the regulations.

5.2.5 Take-off Flight Path Obstacle Clearance

The information regarding take-off flight path obstacle clearance is contained in the AN(HK)O. Accordingly, an obstacle is included in the path of the aeroplane if the distance from the obstacle to the nearest point on the ground below the flight path centre line does not exceed a distance of 60 metres plus half the wing span of the aeroplane plus one eighth of the distance from such point to the end of the take-off distance available measured along the intended line of flight of the aeroplane. If the distance exceeds 900 metres, 900 metres can be used.

The net height of an aeroplane shall clear any obstacle in its path by a vertical interval of at least 35 feet and if it is intended that the aircraft shall change its direction of flight by more than 15°, the vertical interval shall not be less than 50 feet during the change of direction.

*5.2.5.1 Obstacle Information*

The aerodrome obstacle charts published in the AIP contain obstacle information including the exact location of each significant obstacle together with a symbol indicative of its type and the elevation and identification of each significant obstacle.

5.2.6 Extended Second Segment Climb (Extended V2 Climb)

An obstacle cleared on the basis of an extended V2 climb must be the last obstacle in the take-off flight path since the third segment distance, using maximum continuous thrust, may not be available from the flight manual. The airworthiness requirements specify a certain minimum climb gradient capability which an aeroplane should achieve at all points in the take-off flight path above 400 foot gross height. When this requirement can be met by an aeroplane at maximum continuous thrust (instead of take-off thrust) with the most critical combination of speed and wing flap position, the maximum level-off height no longer limits the height at which the second segment climb at V2 speed must be terminated. In other words, the V2 climb may be continued until the take-off thrust time-limit is reached.

## 5.3 Climb Limited Take-off Weight

Minimum gross gradients are defined in the appropriate airworthiness requirements for the first, second, third, and final segments of the take-off flight path. Take-off weight becomes climb limited when the available climb gradient equals these minimum gradients. Weight at altitude and ambient temperature within the operational limits established for the aeroplane and with the most unfavourable centre of gravity for each configuration should be provided by the manufacturers or operators.

Minimum gross climb gradients required by JAR for the various segments along the take-off flight path are listed here. These figures are based on the assumption of a critical engine failure before V2.

| | First Segment | Second Segment | Third Segment | Final Segment |
|---|---|---|---|---|
| Two-engined aeroplane | Positive % | 2.4% | 1.2% | 1.2% |
| Three-engined aeroplane | 0.3% | 2.7% | 1.5% | 1.5% |
| Four-engined aeroplane | 0.5% | 3.0% | 1.7% | 1.7% |

5.3.1 Increased V2 Climb (Improved Climb)

Take-off speeds are usually chosen to achieve the shortest safe take-off distances. The selected V2 speed may fall below the speed range for optimum climb gradient in the take-off configuration. When excess take-off distance is available, the climb or obstacle limited take-off weight may be increased by raising the V2 speed. V1 and Vr must also be increased to maintain consistent performance relationships. This technique is called "Increased V2 Climb" or "Improved Climb Performance". This may be used when the take-off weight is take-off climb limited or obstacle limited and the TODA is greater than the TODR for the climb or obstacle limited weight.

## 5.4 Variables affecting Climb Performance

5.4.1 Flap Setting

Large flap settings induce more drag and reduce the climb performance. However, large take-off flap settings reduce V2 speed and the take-off can be achieved in shorter take-off distance. Therefore, for obstacles located close to the runway end, the obstacle distance increases with a larger flap setting. Such slight obstacle distance gains can give a better obstacle limited weight than using smaller flap settings.

5.4.2 Wind

Wind has no effect on the Climb Limited Weight. For Obstacle Limited Weight, flight path angle which determines the obstacle clearance increases with headwind and reduces with tailwind. Hence, Obstacle Limited Weight increases with headwind and reduces with tailwind.

5.4.3 Temperature

Climb performance improves as temperature decreases due to the increase in thrust.

For obstacle limited weight, when temperature decreases, the TODR is reduced due to the true airspeed effect hence the obstacle distance becomes greater.

5.4.4 Pressure Altitude

Low pressure altitude will result in an increase in air mass flow rate and a lower true airspeed than at high pressure altitude due to the increase in air density. Thus the climb performance improves when pressure altitude decreases.

5.4.5 Slope

Runway slope has no effect on Climb Limited Weight. However, obstacle heights are generally referenced to the elevation at the end of the TODA. When obstacle clearance is critical for a sloped runway, only part of the runway length may be used in order to increase the obstacle distance. In such case, the flight path begins at a higher elevation on a downhill runway, and a lower elevation on an uphill runway.

5.4.6 Level off height

When an obstacle is in the third segment, it is supposed to be cleared by the aeroplane during the level-flight acceleration and flap retraction segment of the calculated flight path. Therefore, the necessary obstacle clearance height must be attained at, or before, the end of the second segment. When a higher obstacle exceeds the maximum level off height, either a reduction in the take-off weight or an extended segment climb is required.

5.4.7 Increased V2 Technique

The technique of increased V2 can be used to enhance climb performance when the TODA is greater than TODR for the climb or obstacle limited weight (see 5.3.1).

# 6. REDUCED THRUST AND DERATED THRUST TAKE-OFF

## 6.1 Reduced Thrust Take-off

The purpose of using reduced thrust take-off is to reduce engine wear associated with maximum thrust operation. Its use may result in the aeroplane operating at or near weight limits due to field length, take-off climb or net flight path minimum where, under the same conditions and aeroplane configuration at rated take-off thrust, the aeroplane would not be limited.

6.1.1 Assumed Temperature Method

Assumed Temperature Method is a technique for determining the take-off performance with all engines operating at less than a full rated take-off thrust rating. The method consists of using the performance data at an assumed temperature higher than the actual ambient temperature to determine weight limits, speeds, take-off thrust setting and take-off flight path information.

Reduced thrust may only be used if the aeroplane meets all applicable performance requirements at the planned take-off weight and reduced thrust setting, and the amount of thrust reduction does not exceed 25 percent of the full rated take-off rating. Full rated take-off rating is the take-off rating of the engines actually installed on the aeroplane, or any derate for which performance data are included in the flight manual. Performance limits are determined by reading the performance charts at an assumed airport temperature higher than the actual ambient temperature. The higher the assumed temperature, the greater the thrust reduction that will be achieved. Therefore, the analysis usually involves determination of the maximum assumed temperature for the actual conditions.

6.1.2 Limitations on the Use of Reduced Thrust

The allowable thrust reduction is such that:

(a) aeroplane performance at the reduced thrust meets all applicable performance requirements, and

(b) the take-off thrust reduction does not exceed 25 percent of the rated take-off thrust.

As a condition to the use of reduced thrust procedures, operators must establish a periodic check system to insure that the engines are capable of producing full take-off thrust.

Use of reduced thrust procedures is not allowed when the take-off runway is contaminated with standing water, ice, slush, or snow.

Use of reduced thrust procedures is allowed on a wet runway if suitable performance accountability is made for the increased stopping distance on the wet runway.

## 6.2 Derated Thrust Take-off

The purpose of using derated thrust take-off is to reduce engine wear associated with maximum thrust operation. Its use is optional and may result in the aeroplane operating at or near weight limits due to field length, take-off climb or net flight path minimum where, under the same conditions and aeroplane configuration at full-rated take-off thrust, the aeroplane would not be limited. Certificate limitations to operate the aeroplane at the derated engine ratings have to be provided in the Flight Manual.

Derated thrust take-off procedure does not permit the selection of maximum rated thrust in an emergency. Hence for a particular thrust setting, derated thrust take-off procedure provides an operational benefit over reduced thrust take-off procedure by allowing the use of reduced minimum control speeds and so a lower V1 can be selected.

Under derated thrust operations, the approach and landing climb performance must be based on the corresponding derate, unless it has been determined that the engines are capable of achieving full rated take-off thrust. In such case, the approach and landing climb performance *could* be based on the full take-off rating of the engines, however, periodic take-offs *should* be conducted at the full take-off rating so as to ensure the availability of full rated thrust when needed.

As a condition to the use of derated thrust, operators must assure that engines are capable of achieving full rated take-off thrust, including full power lever angle capability, without exceeding the corresponding certificated engine limits.

# 7. EN-ROUTE PERFORMANCE

## 7.1 Introduction

The en-route phase of performance assessment pertains to that portion of the flight which starts at a minimum altitude of 1500 feet above the departure aerodrome which is the end of the take-off flight path, and ends 1500 feet above the destination or alternate aerodrome.

## 7.2 Altitude Capability

Altitude capability of an aeroplane is limited by the engine thrust and the manoeuvring capability.

### 7.2.1 Thrust Limited Altitude

The regulation requires that the en-route flight path must be determined with the critical engine(s) inoperative. After engine failure in cruise, the aeroplane will drift down to a stabilising altitude where the gradient is zero and the aeroplane can fly level. The net gradient is used to establish enroute performance requirements specified in the AN(HK)O. If the engine failure occurs on the climb, the aeroplane will reach the same stabilising altitude theoretically where the gradient is zero and the aeroplane can fly level. For certification purpose, the performance data for one or two engines inoperative should be predicated on the assumption that the other power unit or units are operating within the maximum continuous power conditions specified.

Stabilising altitude is affected by the aircraft air conditioning packs. Adjustments to the altitude should be made for different air conditioning packs setting. Furthermore, the stabilising altitude should not exceed the specified maximum permissible altitude for power unit restarting.

### 7.2.2 Buffet Limited Altitude

Airworthiness requirements specify that adequate manoeuvring capability must be available at all speeds and altitudes used in normal operation without encountering buffet onset, or without exceeding the maximum demonstrated lift coefficient. Higher manoeuver margins are required at the rough air speed when severe turbulence is predicted or expected. The limits for normal cruise are based on a 0.3g manoeuver margin to buffet onset.

The buffet boundary is a basic characteristic of the aeroplane which is determined by the angle of attack and mach number. When the airspeed of the aeroplane is lower than stall speed or higher than the critical mach number, the airflow starts to separate from the wing and buffet onset occurs.

## 7.3 Terrain Clearance Performance Requirements

The requirements are given in Air Navigation (General) Regulations of the AN(HK)O.

Enroute performance following engine failure must be assessed using the net data which is the gross data reduced by the following climb gradients as specified in the JAR.

| | One engine inoperative | Two engines inoperative |
|---|---|---|
| Two engined aeroplane | 1.1% | - |
| Three-engined aeroplane | 1.4% | 0.3% |
| Four-engined aeroplane | 1.6% | 0.5% |

### 7.3.1 Minimum Altitude Requirements

Article 32(g) of the AN(HK)O states that the commander of a flying machine registered in Hong Kong shall satisfy himself before take-off that, 'having regard to the performance of the flying machine in the conditions to be expected on the intended flight, and to any obstructions at the places of departure and intended destination and on the intended route, it is capable of safely taking off, reaching and maintaining a safe height thereafter, and making a safe landing at the place of intended destination.'

Rule 25 in Schedule 14 (Rules of the Air) of the AN(HK)O further specifies that 'in order to comply with the Instrument Flight Rules an aircraft shall not fly at a height of less than 1,000 feet above the highest obstacle within a distance of 5 nautical miles of the aircraft unless:

(a) it is necessary for the aircraft to do so in order to land; or
(b) the aircraft is flying on a route notified for the purpose of this Rule; or
(c) the aircraft has been otherwise authorised by the competent authority; or
(d) the aircraft is flying at an altitude not exceeding 3000 feet above mean sea level and remains clear of cloud and in sight of service.'

The above two regulations describe the terrain clearance specifications for operators of Hong Kong-registered aeroplanes and/or aeroplanes flying within Hong Kong airspace. When appropriate, the operator should also impose a more restrictive Minimum Safe Altitude (MSA) constraint to meet its own operational needs and/or the Air Operator Certificate (AOC) requirements.

7.3.2 One Engine Inoperative Requirements

Regulation requires that an aeroplane should, in the event of any one of the power units becoming inoperative at any point on its route or on any planned diversion, be capable of continuing the flight to an alternate aerodrome at which it can comply with a safe landing. On arrival over such aerodrome, the gradient of the specified net flight path, with one power unit inoperative and the other power unit(s) operating within the maximum continuous power conditions specified, shall not be less than zero at 1,500 feet above the aerodrome.

The aeroplane must be capable of clearing by a vertical interval of at least 2,000 feet from obstacles within 10 nautical miles either side of the intended track to an aerodrome. If navigation aids can be made use of by the aeroplane on the route, that the commander of the aeroplane will be able to maintain his intended track on that route within a margin of 5 nautical miles, then 5 nautical miles either side of the intended track can be used.

7.3.3 Two Engines Inoperative Requirements

In the case of an aeroplane having three or more power units and when an aeroplane is more than 90 minutes flying time from the nearest aerodrome at which it can make a safe landing, two engines inoperative terrain clearance is required. In the event of any two power units becoming inoperative at any point on its route or on any planned diversion, the aeroplane should be capable of continuing the flight to an alternate aerodrome at which it can comply with a safe landing. On arrival over such an aerodrome, the gradient of the specified net flight path, with two power units inoperative and the other power unit(s) operating within the maximum continuous power conditions specified, shall not be less than zero at 1,500 feet above the aerodrome.

The 90 minutes flying time is calculated at the all power units operating economical cruising speed in still air.

The aeroplane must also be capable of clearing by a vertical interval of at least 2,000 feet from obstacles within 10 nautical miles either side of the intended track to an aerodrome. If navigation aids can be made use of by the aeroplane on the route, that the commander of the aeroplane will be able to maintain his intended track on that route within a margin of 5 nautical miles, then 5 nautical miles either side of the intended track can be used.

7.3.4 Twin Engines Aeroplane Requirements

Detailed Extended Range Twin Operations (ETOPS) requirements can be found in the Hong Kong Civil Aviation Department publication CAD 513.

# 8. LANDING PERFORMANCE

## 8.1 Introduction

The landing weight is limited by the most restrictive of the following requirements:

- a weight at which the required landing distance will not exceed the available landing distance at the destination or alternate airports;
- maximum approach and landing climb weight for airport altitude and forecast temperature; or
- the maximum structural landing weight.

## 8.2 Field Length Limit

### 8.2.1 Landing Field Length

The scheduled landing field lengths are based on standard temperatures (at each weight, altitude and wind within the operational limits) on a level, smooth, hard-surfaced runway. Scheduled dry landing field lengths are maximum performance landing distances from a 50 foot height at landing speed, divided by a factor of not more than 0.6 for turbo-jet powered aeroplanes, or divided by a factor of not more than 0.7 for turbo-propeller powered aeroplanes. Scheduled wet landing field lengths are determined by multiplying the scheduled dry landing field lengths by a factor of at least 1.15. All scheduled landing field lengths must be no more than the LDA declared by the appropriate Authority.

Reverse thrust was not used in establishing these distances.

The speed at 50 feet above the threshold or Vref is the certification final approach speed. It is normally 1.23 Vs1g or 1.3 Vs at the landing configuration.

Maximum manual wheel braking is used with full auto speed brakes.

The landing distance data include correction factors for not more than 50% of the headwind for landing, or not less than 150% of the tailwind for landing.

### 8.2.2 Variables Affecting Field Length Limited Landing Performance

Pressure altitude - The required landing field length is shorter at a low pressure altitude than at a high pressure altitude because of the lower true airspeed corresponding to the Vref at lower pressure altitude.

Wind - Headwind component gives a lower ground speed and hence reduces the required landing field length.

Slope - An uphill slope runway assists the aircraft to decelerate and hence reduces the required landing field length.

Braking device - With braking devices inoperative such as brakes deactivated, anti-skid inoperative, or using manual spoilers, the required landing field length is increased.

## 8.3 Landing Climb Limit

The climb limited landing weight is the more limiting of:
Landing climb – all engines operating
Discontinued approach – one engine inoperative

The gradient requirements are shown as follows:

| | Landing Climb (All Engines) | Discontinued Approach (One Engine Inoperative) |
|---|---|---|
| Two engined aeroplane | 3.2% | 2.1% |
| Three-engined aeroplane | 3.2% | 2.4% |
| Four-engined aeroplane | 3.2% | 2.7% |

The more critical of the two gradient requirements dictates the Landing Climb Limit Weight.

## 8.4 Contaminated Runway Landing Performance

The actual and unfactored landing distance for contaminated runway (wet ice, slush, standing water, loose snow and compacted snow) should be presented to the pilots. However, the required landing distance for contaminated runway should be at least the scheduled wet landing field length (see 8.2.1), or at least 115% of the landing distance determined in accordance with approved contaminated landing distance data or equivalent, accepted by the appropriate Authority, whichever is greater. This figure should be no more than the LDA declared by the appropriate Authority.

## 8.5 Automatic Brake Landing

Stopping distances with automatic wheel brakes are provided for guidance in the selection of the most desirable autobrake setting for the field length available. They are not to be used to determine the required landing field length. The distances show actual (unfactored) distances from touchdown to full stop when using this system.

The automatic wheel brake system is designed to improve the consistency and smoothness of the landing roll-out by modulating brake pressure to achieve a selected decelerated rate. Use of the system is optional and does not relieve the pilot of the responsibility to assure a safe stop within the available runway.

The automatic wheel brake system is normally triggered at touchdown by landing gear truck tilt and main gear wheel spin-up. Therefore, a delay in lowering the nose gear will not defer the application of the brakes. Maximum pedal braking achieves a higher deceleration rate (shorter stopping distance) than the MAX AUTO setting, provided sufficient runway friction is available. The use of reverse thrust is demonstrated to have adverse effects on autobrake stopping distances.

Stopping distance that can be achieved on wet runways depends on the friction characteristics, or slipperiness, of the particular runway. The wet runway stopping distance that is achieved for a given setting should be the higher of:

- the distance produced by the fixed deceleration of the setting; or
- the distance produced by the runway friction available.

A higher setting will produce shorter stopping distances on wet runways if friction characteristics are such to permit the higher deceleration. The use of reverse thrust will decrease wet runway stopping distance when the deceleration is limited by runway friction characteristics. Extremely wet and slippery conditions can result in longer distances than indicated.

### 8.6 Maximum Quick Turnaround Weight

After landing at weights exceeding the maximum quick turnaround weight, the flight crew should wait at least a specified period and confirm that wheel thermal plugs have not melted before making a subsequent take-off. Maximum quick turnaround weight is affected by the airport temperature, pressure altitude, runway slope and wind.

### 8.7 Automatic Landing

The scheduled landing field lengths for automatic landings include the effect of touchdown dispersal and the 5-knot increase in landing speeds for automatic landings, and also show accountability for ILS glideslope, displaced threshold and wind. Automatic landing ground roll distances are usually based on 115% of actual maximum braking performance distances.

**Appendix 1**

**EXTRACTS FROM THE AIR NAVIGATION (HONG KONG) ORDER 1995 (AN(HK)O) REGARDING AEROPLANES OF PERFORMANCE GROUP A IN THEIR CERTIFICATE OF AIRWORTHINESS**

Article 8(4) states that the certificate of airworthiness may designate the performance group to which the aircraft belongs for the purposes of the requirements referred to in Article 29(1) of the AN(HK)O.

Article 29 sketches out the prescribed conditions regarding the weight and performance of an aeroplane used for public transport. For aeroplanes of performance group A, it specifies that:

(1) An aircraft registered in Hong Kong shall not fly for the purpose of public transport, except for the sole purpose of training persons to perform duties in aircraft, unless the relevant requirements specified in Regulation 4 in Schedule 15 to the AN(HK)O in respect of its weight and related performance and flight in specified meteorological conditions or at night are complied with.

(2) The assessment of the ability of an aircraft to comply with paragraph (1) shall be based on the information as to its performance contained in the certificate of airworthiness relating to the aircraft. In the event of the information given therein being insufficient for that purpose such assessment shall be based on the best information available to the commander of the aircraft.

(3) A flying machine registered in Hong Kong when flying over water for the purpose of public transport shall fly, except as may be necessary for the purpose of take-off or landing, at such an altitude as would enable the aircraft-
  (a) if it has one engine only, in the event of the failure of that engine; or
  (b) if it has more than one engine, in the event of the failure of one of those engines, and with the remaining engine or engines operating within the maximum continuous power conditions specified in the certificate of airworthiness relating to the aircraft;

  to reach a place at which it can safely land at a height sufficient to enable it to do so.

Schedule 15 (Air Navigation (General) Regulations) contains the weight and performance requirements with regard to aeroplanes engaged in public transport. For aeroplanes of performance group A, it states in Regulation 2 that:

(1) The assessment of the ability of an aeroplane to comply with the requirement of Regulation 4 (relating in either case to weight, performance and flights in specified meteorological conditions or at night) shall be based on the specified information as to its performance.

(2) In assessing the ability of an aeroplane to comply with conditions (4) and (5) of Regulation 4, account may be taken of any reduction of the weight of the aeroplane which may be achieved after the failure of a power unit by such jettisoning of fuel as is feasible and prudent in the circumstances of the flight and in accordance with the flight manual included in the certificate of airworthiness relating to the aircraft.

(3) In Regulations 2 and 4, unless the context otherwise requires:

"specified" in relation to an aircraft means specified in, or ascertainable by reference to -
(a) the certificate of airworthiness in force under the AN(HK)O in respect of that aircraft; or
(b) the flight manual or performance schedule included in that certificate, or other document, whatever its title, incorporated by reference in that certificate;

"the emergency distance available" means the distance from the point on the surface of the aerodrome at which the aeroplane can commence its take-off run to the nearest point in the direction of take-off at which the aeroplane cannot roll over the surface of the aerodrome and be brought to rest in an emergency without risk of accident;

"the landing distance available" means the distance from the point on the surface of the aerodrome above which the aeroplane can commence its landing, having regard to the obstruction in its approach path, to the nearest point in the direction of landing at which the surface of the aerodrome is incapable of bearing the weight of the aeroplane under normal operating conditions or at which there is an obstacle capable of affecting the safety of the aeroplane;

"the take-off distance available" means either the distance from the point on the surface of the aerodrome at which the aeroplane can commence its take-off run to the nearest obstacle in the direction of take-off projecting above the surface of the aerodrome and capable of affecting the safety of the aeroplane or one and one half times the take-off run available whichever is the less;

"the take-off run available" means the distance from the point on the surface or the aerodrome at which the aeroplane can commence its take-off run to the nearest point in the direction of take-off at which the surface of the aerodrome is incapable of bearing the weight of the aeroplane under normal operating conditions.

(4) For the purposes of Regulations 2 and 4:

(a) the weight of the aeroplane at the commencement of the take-off run shall be taken to be its gross weight including everything and everyone carried in or on it at the commencement of the take-off run;

(b) the landing weight of the aeroplane shall be taken to be the weight of the aeroplane at the estimated time of landing allowing for the weight of the fuel and oil expected to be used on the flight to the aerodrome at which it is intended to land or alternate aerodrome, as the case may be;

(c) where any distance referred to in paragraph (3) of this Regulation has been declared in respect of any aerodrome by the authority responsible for regulating air navigation over the territory of the Contracting State in which the aerodrome is situated and in the case of an aerodrome in Hong Kong notified, that distance shall be deemed to be the relevant distance.

(5) Nothing in Regulations 2 and 4 shall apply to any aircraft flying solely for the purpose of training persons to perform duties in aircraft.

Regulation 4 of Schedule 15 to AN(HK)O requires that:

With reference to Article 29(1) of the AN(HK)O an aeroplane registered in Hong Kong in respect of which there is in force under the AN(HK)O a certificate of airworthiness in which the aeroplane is designated as being of performance group A shall not fly for the purpose of public transport unless the weight of the aeroplane at the commencement of the take-off run is such that the following conditions are satisfied:

(1) That weight does not exceed the maximum take-off weight for altitude and temperature specified for the altitude and the air temperature at the aerodrome at which the take-off is to be made.

(2) The take-off run, take-off distance and the emergency distance respectively required for take-off, specified as being appropriate to -
(a) the weight of the aeroplane at the commencement of the take-off run;
(b) the altitude at the aerodrome;
(c) the air temperature at the aerodrome;
(d) the condition of the surface of the runway from which the take-off will be made;
(e) the slope of the surface of the aerodrome in the direction of take-off over the take-off run available, the take-off distance available and the emergency distance available, respectively; and

(f) not more than 50 per cent of the reported wind component opposite to the direction of take-off or not less than 150 per cent of the reported wind component in the direction of take-off,

do not exceed the take-off run, the take-off distance and the emergency distance available, respectively, at the aerodrome at which the take-off is to be made; in ascertaining the emergency distance required, the point at which the pilot is assumed to decide to discontinue the take-off shall not be nearer to the start of the take-off run than the point at which, in ascertaining the take-off run required and the take-off distance required, he is assumed to decide to continue the take-off, in the event of power unit failure.

(3) (a) The net take-off flight path with one power unit inoperative, specified as being appropriate to:-

(i) the weight of the aeroplane at the commencement of the take-off run;

(ii) the altitude at the aerodrome;

(iii) the air temperature at the aerodrome; and

(iv) not more than 50 per cent of the reported wind component opposite to the direction of take-off or not less than 150 per cent of the reported wind component in the direction of take-off,

and plotted from a point 35 feet or 50 feet, as appropriate, above the end of the take-off distance required at the aerodrome at which the take-off is to be made to a height of 1,500 feet above the aerodrome, shows that the aeroplane will clear any obstacle in its path by a vertical interval of at least 35 feet; and if it is intended that the aeroplane shall change its direction of flight by more than 15° the vertical interval shall not be less than 50 feet during the change of direction.

(b) For the purpose of sub-paragraph (a) hereof an obstacle shall be deemed to be in the path of the aeroplane if the distance from the obstacle to the nearest point on the ground below the intended line of flight of the aeroplane does not exceed -

(i) a distance of 60 metres plus half the wing span of the aeroplane plus one eighth of the distance from such point to the end of the take-off distance available measured along the intended line of flight of the aeroplane; or

(ii) 900 metres,

whichever is the less.

(c) In assessing the ability of the aeroplane to satisfy this condition, it shall not be assumed to make a change of direction of a radius less than the specified radius of steady turn.

(4) The aeroplane will, in the meteorological conditions expected for the flight, in the event of any one power unit becoming inoperative at any point on its route or on any planned diversion therefrom and with the other power unit or units operating within the maximum continuous power conditions specified be capable of continuing the flight, clearing by a vertical interval of at least 2,000 feet obstacles within 10 nautical miles either side of the intended track to an aerodrome at which it can comply with condition (7) in this Regulation relating to an alternate aerodrome and on arrival over such aerodrome the gradient of the

specified net flight path with one power unit inoperative shall not be less than zero at 1,500 feet above the aerodrome, and in assessing the ability of the aeroplane to satisfy this condition it shall not be assumed to be capable of flying at an altitude exceeding the specified maximum permissible altitude for power unit restarting:

Provided that where the operator of the aeroplane is satisfied, taking into account the navigation aids which can be made use of by the aeroplane on the route, that the commander of the aeroplane will be able to maintain his intended track on that route within a margin of 5 nautical miles, the foregoing provisions of this paragraph shall have effect as if 5 nautical miles were substituted for 10 nautical miles.

(5) In the case of an aeroplane having three or more power units, it will, in the meteorological conditions expected for the flight, in the event of any two power units becoming inoperative at any point along the route or on any planned diversion therefrom more than 90 minutes flying time in still air at the all power units operating economical cruising speed from the nearest aerodrome at which it can comply with condition (7) in this Regulation, relating to an alternate aerodrome, be capable of continuing the flight with all other power units operating within the specified maximum continuous power conditions, clearing by a vertical interval of at least 2,000 feet obstacles within 10 nautical miles either side of the intended track to such an aerodrome, and on arrival over such an aerodrome the gradient of the specified net flight path with two power units inoperative shall not be less than zero at 1,500 feet above the aerodrome; and in assessing the ability of the aeroplane to satisfy this condition it shall not be assumed to be capable of flying at an altitude exceeding the specified maximum permissible altitude for power unit restarting:

Provided that where the operator of the aeroplane is satisfied taking into account the navigation aids which can be made use of by the aeroplane on the route, that the commander of the aeroplane will be able to maintain his intended track on the route within a margin of five nautical miles, the foregoing provisions of this paragraph shall have effect as if five nautical miles were substituted for 10 nautical miles; or

In the case of an aeroplane having two power units and a maximum total weight authorised which exceeds 5,700 kg, and which is not limited by its certificate of airworthiness to the carriage of less than 20 passengers, it will, in the meteorological conditions expected for the flight, at any point along the route or on any planned diversion therefrom, not be more than 60 minutes flying time at the normal one engine inoperative cruise speed in still air from the nearest aerodrome at which it can comply with condition (7) in this Regulation, relating to an alternate aerodrome, unless it is flying under and in accordance with the terms of any written permission granted by the Governor to the operator under this Regulation; or

In the case of an aeroplane having two power units and a maximum total weight authorised of 5,700 kg or less or in the case of an aeroplane having two power units and a maximum total weight authorised of more than 5,700 kg, but which is limited by its certificate of airworthiness to the carriage of less than 20 passengers the aeroplane will, in the meteorological conditions expected for the flight, not be more than 90 minutes flying time in still air at the all power units operating economical cruising speed from the nearest aerodrome at which it can comply with condition (7) in this regulation, relating to an alternate aerodrome.

(6) The landing weight of the aeroplane will not exceed the maximum landing weight specified for the altitude and the expected air temperature for the estimated time of landing at the aerodrome at which it is intended to land and at any alternate aerodrome.

(7) (a) (i) In the case of a turbine-jet powered aeroplane, the landing distance required does not exceed at the aerodrome at which it is intended to land or at any alternate aerodrome, as the case may be, the landing distance available on -

(aa) the most suitable runway for a landing in still air conditions; and

(bb) the runway that may be required for landing because of the forecast wind conditions.

(ii) In the case of an aeroplane powered by turbine propeller or piston engines, the landing distances required, respectively specified as being appropriate to aerodromes of destination and alternate aerodromes, do not exceed at the aerodrome at which it is intended to land or at any alternate aerodrome, as the case may be, the landing distance available on -

(aa) the most suitable runway for a landing in still air conditions; and

(bb) the runway that may be required for landing because of the forecast wind conditions:

Provided that if an alternate aerodrome is designated in the flight plan, the specified landing distance required may be that appropriate to an alternate aerodrome when assessing the ability of the aeroplane to satisfy this condition at the aerodrome of destination.

(b) For the purposes of sub-paragraph (a) hereof the landing distance required shall be that specified as being appropriate to -

(i) the landing weight;

(ii) the altitude at the aerodrome;

(iii) the temperature in the specified international standard atmosphere appropriate to the altitude at the aerodrome;

(iv) (aa) a level surface in the case of runways usable in both directions;

(bb) the average slope of the runway in the case of runways usable in only one direction; and

(v) (aa) still air conditions in the case of the most suitable runway for a landing in still air conditions;

(bb) not more than 50 per cent of the forecast wind component opposite to the direction of landing in the case of the runway that may be required for landing because of the forecast wind conditions.

**Appendix 2**

# CERTIFICATION DIFFERENCES - BRITISH CIVIL AIRWORTHINESS REQUIREMENTS (BCAR)

## 1. Definitions

Screen Height

The height of an imaginary screen which the aeroplane would just clear when taking off or landing in an unbanked attitude with landing gear extended.

Vat

Target Threshold Speed, Vat – The speed at which the pilot should aim to cross the runway threshold to ensure the scheduled landing field lengths are consistently achieved. The speeds at the threshold are: $Vat_0$ – all engines operating; $Vat_1$ – a critical engine inoperative.

Vtmax

Maximum Threshold Speed, Vtmax – The speed at the threshold above which the risk of exceeding the scheduled landing field length is unacceptably high. This speed is normally $Vat_0$ + 15 knots.

## 2. Take Off Distance Required (TODR)

The TODR is the greatest of:

- 1.15 times the gross distance to accelerate with all engines operating from the starting point to the rotation speed, to effect a transition to climbing flight and attain a screen height of 35 feet; the speed at 35 feet shall not be less than V2, and shall be consistent with the achievement of a smooth transition to V4 at a height of 400 feet;

- The gross distance to accelerate with all engines operating from the starting point to the dry runway engine failure point, then to accelerate with the critical engine inoperative to the rotation speed, and thereafter to effect a transition to climbing flight and attain a screen height of 35 feet at a speed not less than V2; and

- The gross distance to accelerate with all engines operating from the starting point to the wet runway engine failure point, then to accelerate with the critical engine inoperative to the rotation speed, and thereafter to effect a transition to climbing flight and attain a screen height of 15 feet in a manner consistent with the achievement of a speed not less than V2 at 35 feet.

## 3. Take Off Run Required (TORR)

The TORR is the greatest of:

- 1.15 times the sum of the gross distance from the starting point to the point where the aeroplane becomes airborne, and one-third of the gross distance between the point at which the aeroplane becomes airborne and the point at which it attains a screen height of 35 feet with all engines operating;

- The gross distance from the starting point to the point where the aeroplane becomes airborne plus one-third of the gross distance between the point at which the aeroplane becomes airborne and the point at which it attains a screen height of 35 feet with one engine inoperative from the dry runway engine failure point; and

- The gross distance from the starting point to the point where the aeroplane becomes airborne with one engine inoperative from the wet runway engine failure point.

## 4. Accelerate-Stop Distance Required (ASDR)

The ASDR is the greater of:

- The gross distance to accelerate with all engines operating from the starting point to the dry runway engine failure point, to effect a transition to the braking configuration, and to stop; or,

- The gross distance to accelerate with all engines operating from the starting point to the wet runway engine failure point, to effect a transition to the braking configuration, and to stop.

## 5. Take-off Climb

Minimum gross climb gradients required by BCAR for the various segments along the take-off flight path are listed here. These figures are based on the assumption of a critical engine failure.

| | First Segment[1] | Second Segment | Third Segment | Final Segment |
|---|---|---|---|---|
| Two-engined aeroplane | Positive % | 2.4% | 1.2% | 1.2% |
| Three-engined aeroplane | 0.3% | 2.7% | 1.4% | 1.4% |
| Four-engined aeroplane | 0.5% | 3.0% | 1.5% | 1.5% |

[1] The selection of Maximum Contingency Power is assumed to be automatic for these figures.

## 6. Enroute Climb

Enroute performance following engines failure must be assessed using the net data which is the gross data reduced by the following climb gradients as specified in the BCAR.

| | One engine inoperative | Two engines inoperative |
|---|---|---|
| Two engined aeroplane | 1.1% | - |
| Three-engined aeroplane | 1.3% | 0.0% |
| Four-engined aeroplane | 1.4% | 0.3% |

## 7. High Altitude Manoeuvre Limits

Airworthiness requirements specify that adequate manoeuvring capability must be available at all speeds and altitudes used in normal operation without encountering buffet onset, or without exceeding the maximum demonstrated lift coefficient. Higher manoeuvre margins are required at the rough air speed when severe turbulence is predicted or expected.

The limits for normal cruise at altitude are based on the more limiting of a 0.6g manoeuvre margin to the maximum demonstrated lift coefficient, which is defined as the maximum intensity of buffet at which aeroplane controllability and structural integrity are unimpaired, or a 0.3g manoeuvre margin to buffet onset.

When severe turbulence is forecast, the altitude limit may represent the maximum altitude at which a 0.8g manoeuvre margin to maximum demonstrated lift coefficient is achieved at the rough air speed or 0.4g manoeuvre margin to buffet onset at the rough air speed, whichever is more limiting.

## 8. Landing Climb

Final En-route

At a height of 1,500 feet above the landing surface the one engine inoperative net en-route gradient of climb shall be positive.

Continued Approach - All Engine Operating

At the altitude of the landing surface the gross gradient of climb in free air, with the aeroplane in the all engines operating final approach configuration and at the final steady approach speed scheduled for all engines operating approaches and with all engines operating within maximum continuous power limitations, shall be positive.

Continued Approach - One Engine Inoperative

At the altitude of the landing surface the gross gradient of descent, in free air, with the aeroplane in the one engine inoperative final approach configuration and at the final steady approach speed scheduled for one engine inoperative approaches, with the critical engine inoperative and with the operating engines operating within intermediate contingency power limitations, shall be not greater than -

2.0% for aeroplanes with two engine units,
1.8% for aeroplanes with three engine units,
1.6% for aeroplanes with four engine units.

Discontinued Approach

At the altitude of the landing surface, the gross gradient of climb in free air shall be not less than-

1.1% for aeroplanes with two engine units,
1.3% for aeroplanes with three engine units,
1.4% for aeroplanes with four engine units.

Balked Landing

At the altitude of the landing surface the gross gradient of climb shall be not less than 3.2%.

## 9. Landing Distance Required (LDR)

All scheduled LDR are either based on landing on a dry hard surface from a screen height of 50 feet in accordance with the BCAR Arbitrary Landing Distance; or landing on a smooth, wet, hard-surfaced runway from a height of 30 feet with Vtmax specified in the BCAR Reference Landing Distance. Calculated distances account for conservative reaction times, full reverse thrust on all operating engines (if installed and certified), and demonstrated braking coefficients.