
# B747
# Three Engine Ferry
# Manual

Revision 1
10 Dec 17

# 0 Record of Amendments

| Change | Subject | Moved To | Date | Amended By |
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# Contents

# 1 Limitations

## 1.1 General

In addition to the normal limits found in the Operations Manuals, the following limitations apply to three engine ferry operations.

### 1.1.1 Purpose

The aircraft shall only fly for the purpose of reaching a place at which the defective power unit can be rectified or replaced. It shall not be used for public transport or aerial work.

### 1.1.2 Crew

The Captain of a three engine ferry flight will always be designated and have completed three engine ferry training, and will always act as PF for the take off and clean up flight phases. Once the aircraft is clean there is no restriction on PF duties. Three engine ferry flights will be available to BAV Senior Captains only.

When a 3EFF operation is planned the commander (who will always be qualified and designated) is responsible for briefing and training the first officer in his specific role and responsibilities.

The crew should be limited to essential operating crew members only, but such operations will often require the use of a relief crew. Any such pilot should be briefed in a similar way to the operating first officer but it should be noted that relief crewmember's duties are no different from a normal line flight continuation policy.

The operation is covered by an approved Boeing Aircraft Flight Manual Appendix and is operated by line crew as part of their normal duties.

## 1.2 Operational Limitations

### 1.2.1 Maximum Airspeed

Do not exceed 320 KIAS/0.85 M.

### 1.2.2 Take-off Performance Limit (TOPL) Weight

The TOPL Weight should be requested by using CARD.

### 1.2.3 Take-off EPR

Derate 2 (TO 2) must be used for take-off.

### 1.2.4 Take-off Configuration

Take-off shall be made using Flap 10

### 1.2.5 Runway Condition

Take-off is not permitted on contaminated runway (i.e. standing water greater than 3 mm, ice, slush, snow or slippery). The pressure altitude of the departure runway must not be greater than 9500 ft.

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### 1.2.7 Weather Conditions

The visibility and cloud ceiling prevailing at the airport of departure, and forecast for the destination and alternate airports, shall not be less than 3 km and 1,000 ft respectively.

EASA recommends 3 km and 500 ft as forecast minima at destination and alternate airfields, but the over-riding requirement is for the captain to always be able to reach an airfield where a two engine approach and landing can be safely carried out whilst utilizing the minima available for the likely one engine inoperative approach iaw BA flight continuation policy.

### 1.2.8 Icing Conditions

Areas of predicted or reported icing conditions should be avoided. If icing is encountered a restriction of 270 kt/Mach 0.8 should be adhered to.

### 1.2.9 Limiting Crosswind Component

For take-off the crosswind component of the tower-reported or forecast wind velocity must not exceed 7 K from the side on which the unserviceable engine is located. The normal crosswind limits for one or two engines inoperative should be observed for landing.

### 1.2.10 Range from Alternate Airfields

The flight should be conducted such that the aircraft can always reach an airfield where a two engine inoperative approach and landing can be carried out.

### 1.2.11 Fuel Requirements

Normal BAV fuel requirements apply. In the absence of PFPX/Simbrief three engine ferry performance data, crews should reference the one engine inoperative data in the FCOM and QRH for cruise level capability and additional fuel consumption. Three engine fuel consumption is not significantly greater than all engines operative fuel consumption, but crews should allow a conservative margin on top of standard AEO fuel plans.

# 2 Normal Procedures

## 2.1 Preparation

Four cowled engines must be installed. Any one engine may be inoperative. The inoperative engine must be in one of the following configurations:

1. Fan Removed
2. Windmilling
3. Powerplant Engineering must have been consulted for a statement on the condition of the three serviceable engines. Borescope inspection of the three serviceable engines may not be necessary unless there is a suspicion of internal damage (e.g. following a multiple birdstrike). If borescope inspections are not required, Powerplant Engineering will issue an Engineering Order to alleviate the requirements.
4. The following remaining equipment must be serviceable:

    - Anti-skid and all braking systems (excluding autobrake).
    - 3 electrical generator channels.
    - 3 bleed air pneumatic systems.
    - 4 hydraulic demand pumps.
    - All fuel pumps associated with the fuel tanks in use.
    - Fuel jettison system.

5. Any equipment deficiencies which have an associated performance penalty have been discussed with Flight Management, e.g. EPR indication.
6. All revenue payload must be removed (non-revenue flight).
7. Aircraft Library and charting software contents must be reviewed prior to departure from home base, to ensure adequate documentation (charts) for the planned route.

## 2.2 Planning

Use TOPCAT to request and take-off vital data information for the runways likely to be in use. Figures for Flap 10 and TO2 with no assumed temperature can be used.

If the TOPL is likely to be restrictive consider offloading all catering equipment and potable water. This can reduce the ZFW by up to 7,000 kg.

For flights within US airspace ensure that an FAA Special Flight Authorisation for a three engine ferry flight will be obtained. Such an authorisation is essential for flights within US airspace. Once received, confirm the expiry date of the Authorisation.

For flights within Canadian airspace ensure that the three engine ferry authorisation is valid.

It is recommended that three engine ferry flights are not dispatched into regions of predicted or reported icing conditions. Whilst this is recommended, there may well be a favourable balance between limited exposure to icing as against having to re-route with a possible extra sector.

## 2.3 Pre-flight Checks

Perform all normal pre-flight checklists except at the appropriate point:

1. Set MDA display to the second engine failure acceleration altitude.
2. Set planned acceleration altitude in the E/O acceleration altitude field on the Take-off page.
3. Do not select ENG OUT prompt on the FMS VNAV CLB or CRZ pages.
4. Select TO 2 (Derate 2 take-off thrust) and CLB (full climb thrust).
5. Select Flap 10.
6. LNAV may be used.
7. VNAV may be used.
8. Select Autothrottle Off
9. Carry out packs off or one pack on take-off procedure.
10. Place the ground proximity GEAR OVERRIDE switch to OVRD.

## 2.4 Taxiing

The Transponder should be selected to TA only.

In the event of a long taxi maintain fuel symmetry by selective use of cross-feed valves and booster pumps and ensure the correct configuration is established before take-off.

## 2.5 Take-off

Aircraft handling during take-off differs significantly from the normal procedures. Care is necessary to ensure that directional control is maintained during the take-off roll yet it is also important that take-off thrust is set on the asymmetric engine expeditiously. The aim is that take-off EPR will be set on the symmetrical engines with the aircraft stationary. Brakes are then released and thrust is progressively increased on the asymmetric engine during the take-off run at a rate which is commensurate with directional control being retained.

## 2.6 Take-off Technique

1. Do not preset the rudder trim.
2. Align the aircraft with the runway centre line and apply foot brakes. Press TOGA to update the ND if GPS is unserviceable.
3. The Co-pilot will:
   a. Hold the control column forward applying necessary aileron inputs for crosswind. Note that at higher speeds the nose will naturally want to lift and this should be resisted.
   b. Call out EPR and speeds in 20 KIAS intervals, recommended commencing at 40 KIAS. Note that power should not be increased on the assymetric engine below 50 kts.
   c. When flaps are up set CON thrust on the FMC Thrust Lim page.
4. The Captain will:
   a. Set take-off thrust on the symmetric engines and advance the 'dead' engine thrust lever.
   b. Release the brakes and apply 1.03 EPR on the remaining operating engine.
   c. As the aircraft accelerates, the Captain simultaneously advances the operable engine's thrust lever (not below 50 KIAS) and maintains directional control using the tiller and rudder pedals. It is recommended that steering inputs be made primarily using the rudder fine steering. The tiller should be guarded and only used with extreme caution in the event of insufficient control from the rudder pedals.

d. Steadily increase thrust on the asymmetric engine to attain take-off thrust at a speed near to, but not below VMCG.
e. After the operable engine attains take-off thrust, the Captain takes the control column and completes the take-off and climb out using normal procedures appropriate to three engine climb out.
f. The Flight Director will command V2 - V2 + 10 KIAS during the climb out. With VNAV engaged at Aa an increase in speed will be commanded. If VNAV not engaged at Aa, select FLCH and an increase in speed to VREF + 100 K. When flaps are up, arm autothrottle and check/select THR to CON thrust. Select and execute ENG OUT on the CDU CLB page.
g. When flaps are up select all packs on.
h. Maintain fuel symmetry using cross-feed valves and fuel pumps switches as required.
i. Return the ground proximity GEAR OVERRIDE switch to normal.

**Note 1:** RTO autobrakes are not available when any thrust lever is not advanced however, BAV procedures recommend the "dead engine" thrust lever **is** advanced.

**Note 2:** Do not follow any noise abatement procedure that restricts airspeed.

**Note 3:** Retract gear and flaps as soon as possible.

**One Inboard Engine Inoperative**

Use the same procedure as for take-off with an outboard engine inoperative except that take-off thrust is initially applied on the outboard engine. Increase thrust on the operating inboard engine so that take-off thrust is obtained at 80 to 90 KIAS

## 2.7 Climb and Cruise

1. En-route climb is carried out at the FMC ENG OUT SPD using maximum continuous thrust (CON).
2. Cruise is carried out at ENG OUT LRC (long range cruise) speed. Do not enter speeds which exceed 320 KIAS or 0.85 M.
3. Three engine performance data is contained in the FMC.

## 2.8 Approach and Landing

Carry out the approach and landing in accordance with standard one engine inoperative procedures.

# 3 Emergency Procedures

In addition to the normal and emergency procedures found in the Operations Manuals, the following emergency procedures apply to three engine ferry operations.

## 3.1 Take-off

In the event of an engine failure prior to VSTOP, reject the take-off.

When using TOPCAT for performance calculations VSTOP can be considered equal to $V_1$.

If during the take-off an engine failure occurs on the same side as the inoperative engine then full rudder deflection may be required in order to keep the aircraft straight. At $V_R$, the HP will rotate the aircraft at approximately 2° per second, to a target attitude of about 11°. Once airborne up to 3° of bank towards the live engines is permitted to assist in keeping straight. For any combination of two inoperative engines, initial climb out should be made at V2 and the acceleration should be made, level, at the minimum clean up height as calculated, which will never be less than 400 ft but which may be higher if obstacles are present (see Chapter 4).

## 3.2 Cruise

In the event of an engine failure occurring in the cruise, divert to the nearest suitable airfield. Recheck the MSAs en route and re-confirm the drift down altitude and range performance. The FMS will give two engines inoperative data in this condition. Quick reference drift down altitudes for both one and two engines inoperative are in the QRH.

## 3.3 Two-engined Landing

Following an engine failure the subsequent two-engined landing should be performed in accordance with standard two engine inoperative procedures.

# 4 Performance

## 4.1 CIRRUS

At present there is no three engine performance database for PFPX or Simbrief. However the FMS ENG OUT performance will be accurate.

## 4.2 Take-off Performance Limit (TOPL) Weight

Use TOPCAT to obtain the TOPL weight and take-off speeds using Flap 10, TO2 with no assumed temperature and packs off or one pack on.

The aeroplane may require defuelling.

The three engine ferry take-off performance data is based on:

- Flap 10.
- Minimum acceleration altitude of 400 ft (CARD will show the engine-out acceleration altitude if higher than 400 ft).
- Ignore any Noise Abatement procedure if shown on CARD.
- Take-off Derate 2 (TO2).
- Packs off or one pack on.

## 4.3 Take-off Speeds

TOPCAT will output the maximum stopping speed VSTOP (V1), VR and V2 for actual take-off weight.

## 4.4 Take-off EPR

Use TO2 (Derate 2 take-off thrust) without assumed temperature.

## 4.5 Landing Performance

The Maximum Performance Landing Weight is the lesser of the Field Length Limit Weight and Climb Limit Weight. Do not exceed Maximum Structural Landing Weight.

### 4.5.1 Field Length Limit Weight

1. On the LANDING FIELD LENGTH CORRECTION chart enter the Ferrying Landing Distance scale with Landing Distance Available and read the Normal Landing Distance.
2. On the MAXIMUM LANDING WEIGHT (FIELD LENGTH LIMITS) chart enter the Landing Field Length scale with the Normal Landing Distance obtained in 1, adjusting for wind and proceed to Airport Pressure Altitude and read the Gross Weight.

### 4.5.2 Climb Limit Weight

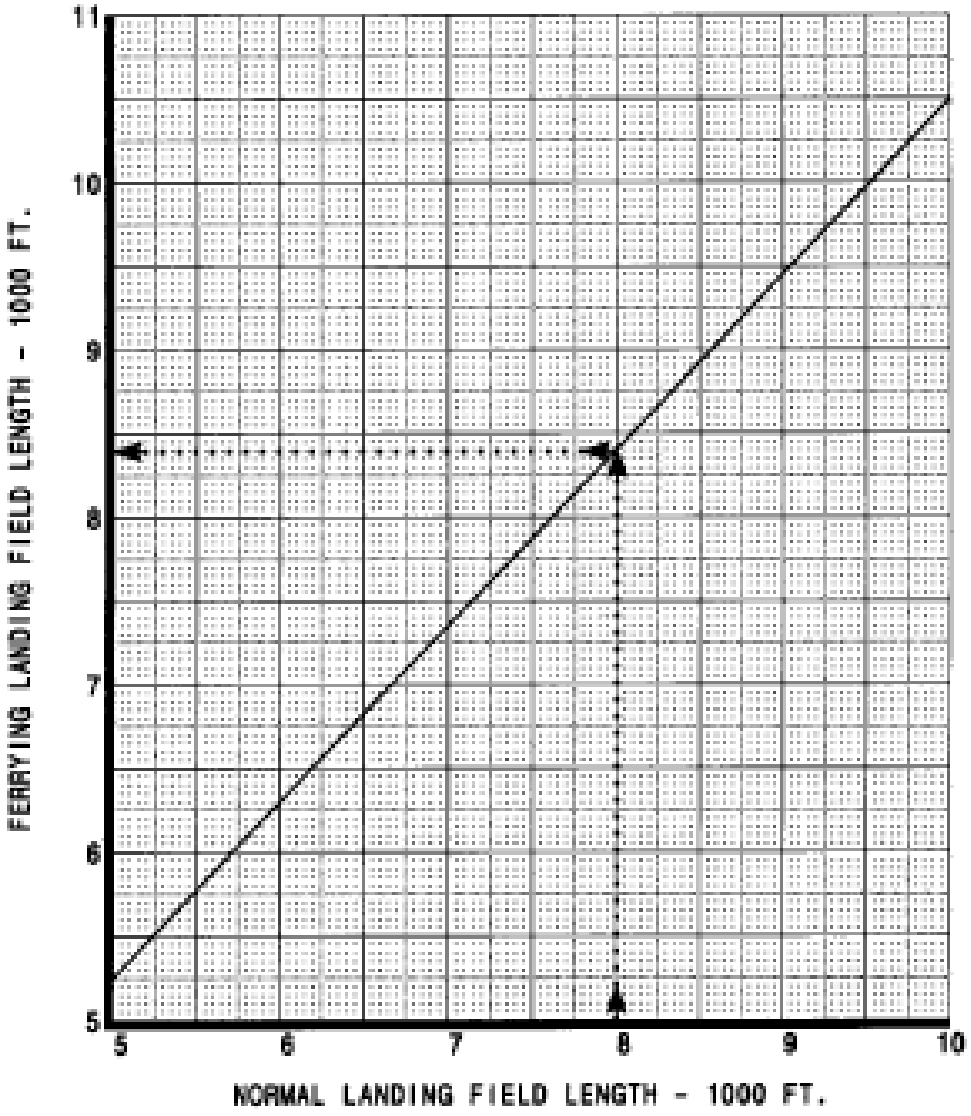
On the MAXIMUM LANDING WEIGHT (CLIMB LIMITS) chart enter the Airport OAT scale to the Pressure Altitude and read the Gross Weight.

### 4.5.2.1 Maximum Landing Weight (Landing Field Length Correction)

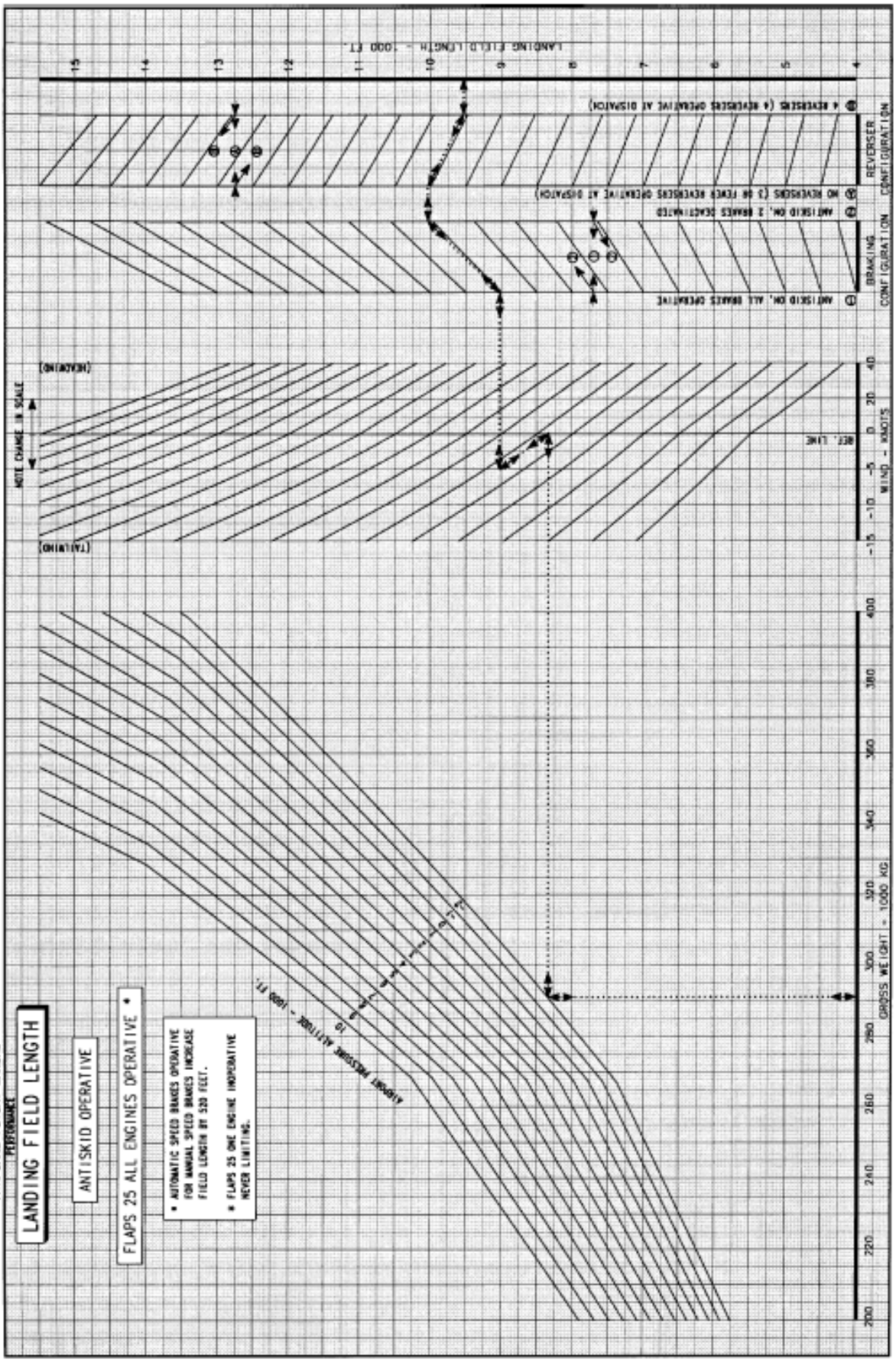
**LANDING FIELD LENGTH CORRECTION**

**FLAPS 25**

**ONE ENGINE INOPERATIVE FERRY**



### 4.5.2.2 Maximum Landing Weight (Field Length Limits)



### 4.5.2.3 Maximum Landing Weight (Climb Limits)

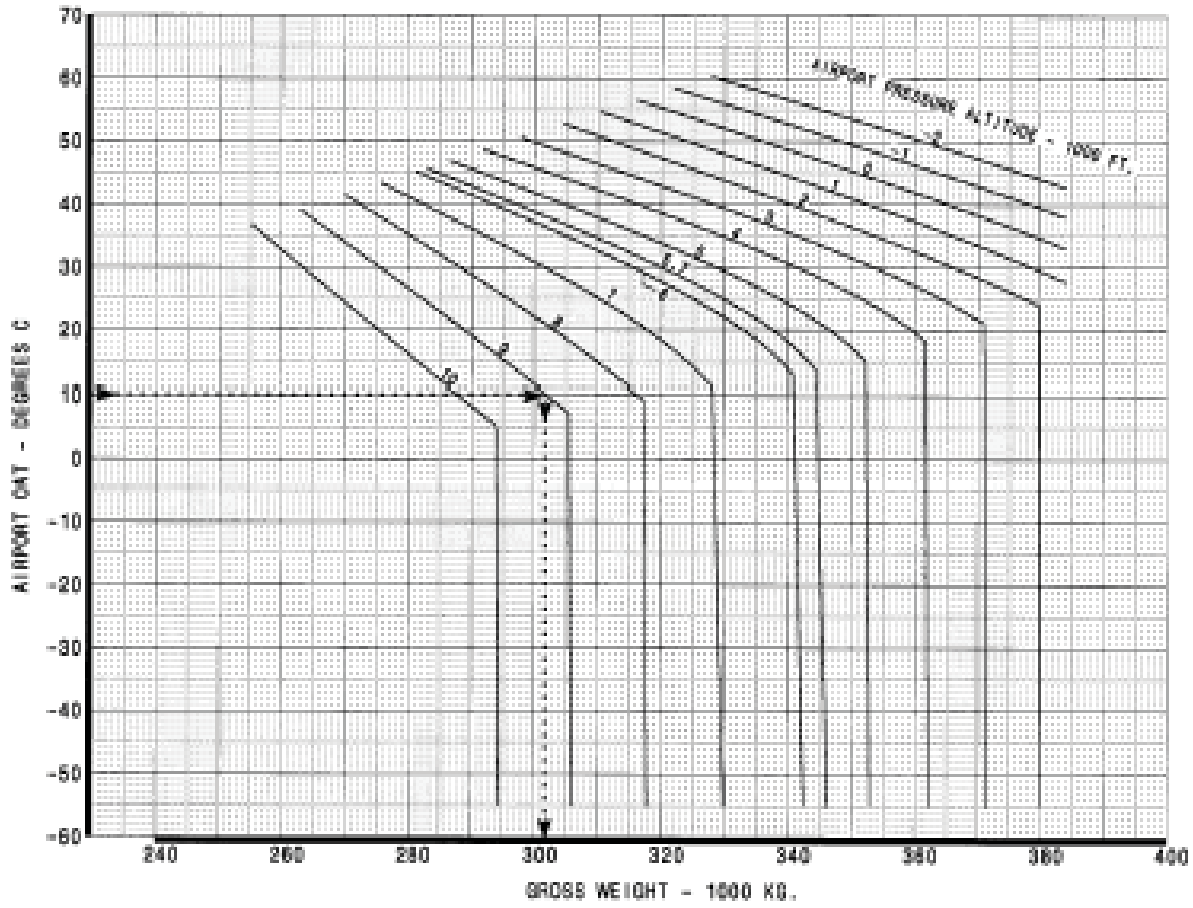
**MAXIMUM LANDING WEIGHT**
CLIMB LIMITS

LANDING FLAPS 25

A/C PACKS OFF

ONE ENGINE INOPERATIVE FERRY

- FOR SPEED SCHEDULE SEE THE APPROPRIATE LANDING CLIMB CHART ON THE BASIC MANUAL
- FOR 1 A/C PACK ON, REDUCE GROSS WEIGHT BY 4500 KG.



# 5 Miscellaneous

## 5.1 Handover Brief

### 5.1.1 Limitations

The only additional limitation applicable to a three engine ferry flight is the maximum speed limitation which is caused by the fact that the inoperative engine creates more drag:

**Maximum Airspeed – Do not exceed:** 320 K/0.85 M

Icing conditions should be avoided but if they are inadvertently encountered limit speed to 270 kt/Mach 0.8

### 5.1.2 Cruise

The FMS three engine database assumes a windmilling engine. Normally for a three engine ferry the fan blades of the inoperative engine have been removed and the core of the engine has been aerodynamically blanked. This produces less drag than the windmilling engine case, and so the fuel predictions will be pessimistic. The fan blades are usually carried on board and their weight is included in the Dry Operating Weight.

Once at cruise altitude fly at the FMS E/O LRC speed. This will require selection of LRC on the ACT E/O CRZ page (E/O speed is much slower and is the optimum three engine drift down speed at minimum rate of descent). CIRRUS three engine cruise speeds are also based upon E/O LRC.

Ensure that at all stages of flight the aircraft has sufficient range and altitude capability to reach a suitable airfield should a second engine fail.

Maintain fuel symmetry through selective use of cross-feeds valves and fuel pumps in accordance with FCOM Supplementary Procedure – Fuel and FCTM Chapter 8, Fuel Guidance.

### 5.1.3 Descent and Landing Procedures

The descent and landing phases are conducted in accordance with normal three engine procedures. The AUW will probably be much lower than you have experienced before. The $V_{REF}$ will be comparatively low and the EPR required will be lower than usual. A common error is to float when landing at these light weights. As this is a non-revenue flight and as an emergency condition does not exist, the Captain may, at his discretion, permit the Co-pilot to land the aircraft.

## 5.2 Transport Canada Clearance for Three Engine Ferries

See Transport Canada CARs Part V, Standard 507 - Flight Authority & Certificate of Noise Compliance (507.04 Paras (3) & (4)) for flight permit application process, and Chapter 505 Schedule B Operating Conditions and Limitations for One Engine Out Ferry Flight and for Prohibited Runways listing.

# 6 Annex A: Aide Memoire

| LIMITATIONS |
|---|
| **CREW…..CPT MUST BE QUALIFIED** |
| **BRIEF….NON-QUALIFIED FLIGHT CREW** |
| **…….NO PAX / FREIGHT OR CABIN CREW** |
| **SPEED…320 KIAS / 0.85 M (WINDMILLING)** |
| **MTOW……..PERFORMANCE LIMIT** |
| **TAKE OFF EPR……TO2** |
| **TAKE OFF FLAP……10°** |
| **TAKE OFF BLEEDS……PACKS OFF or 1 PACK ON** |
| **RUNWAY…… NOT SLIPPERY or CONTAMINATED** |
| **WEATHER……>3km / 1,000ft** |
| **X WIND……7K FROM "DEAD SIDE"** |
| **ICING CONDITIONS….AVOID IF POSSIBLE** |
| **FUEL REQUIREMENTS……NORMAL** |
| **USA…….FAA SPECIAL AUTHORISATION (Ad Hoc)** |
| **CANADA……..…SPECIAL AUTHORISATION (Ad Hoc)** |

Complete all Normal checklist items in the usual sequence + **POSITIONING FERRY FLIGHT ITEMS** [FCOM SP]
Items noted below are additional or modify the normal items.

| PRE-FLIGHT |
|---|
| **FMC-VNAV……ALL ENG THRUST……..TO2** |
| **CLIMB THRUST……...CLB** |
| **A/T……OFF** |
| **A/C PACKS……...OFF or 1 PACK ON** |
| **TCAS……TA Only** |
| **GEAR OVERRIDE……OVRD** |

Charts : have charts available for immediate re-Landing
QRH : One open @ 2 Engine checklist & procedure
RAD / NAV: Pre-select return aids, if possible.
Visually examine any potential obstacles in the take-off path and discuss strategy for immediate return.
Clean Up Height (3 Eng)……?
Clean Up Height (2 Eng) (min 400ft)……?

| TAKE-OFF |
|---|
| **Advise ATC of exact intentions if further engine failure on take-off** |
| **Captain:** |
| **RUDDER TRIM……..ZERO** |
| **FOOTBRAKES……APPLY** |
| **TOGA…….PRESS TO UPDATE POSN.** |
| **TILLER……GUARD** |
| **SYMMETRICAL+DEAD ENGINES.SET TO2** |
| **BRAKES……RELEASE** |
| **ASYMMETRIC ENGINE……SET 1.03 EPR** |
| **POWER……PROGRESSIVELY INCREASE** |
| **CALL……MY WHEEL when POWER SET or V1** |
| **Co-Pilot:** |
| **CONTROL WHEEL……HOLD FORWARD** |
| **AILERON……APPLY AS REQ.** |
| **CALL IAS & EPR……EVERY 20 KIAS** |
| **CALL……POWER SET** |
| **CALL……..V1 @ V STOP or ROTATE if Vr is lower** |

| AFTER TAKE-OFF |
|---|
| **AFTER FLAP UP……SET CON PWR** |
| **A/T……ARM/ENGAGE** |
| **A/C PACKS……...ON** |
| **ABOVE MSA……ENG OUT (VNAV)** |
| **SPEED……...AS REQ** |
| **FUEL……BALANCE** |
| **GEAR OVERRIDE……..NORMAL** |

| CRUISE |
|---|
| **FUEL……BALANCE (see FM SPs)** |
| **……Consider FUEL XFER MAIN 1 & 4** |
| **UPDATE……..2 ENG DATA** |
| **REVIEW……...ENROUTE SITUATION** |

| DESCENT / APPROACH / LANDING |
|---|
| **NORMAL** |

**AIRCRAFT SERVICEABILITY**

The following must be serviceable:

a) All brake systems on all main wheels (Excluding Autobrake)
b) 3 Main Engine Electrical Generators
c) 3 Bleed Air Pneumatic Systems
d) 4 Hydraulic Demand Pumps
e) No hydraulic leaks
f) All tank Pumps for Tanks with Fuel
g) Fuel Jettison System
h) Door 2L + 1 Upper deck door / slide
i) Any equipment deficiencies which have an associated performance penalty have been discussed with Flight Management e.g. EPR indication

**AIRCRAFT PREPARATION**

j) Live Engines certified by Powerplant
k) Engineering. (Boroscope Alleviation)
l) Dead engine prepared as Fan Removed or Wind milling.
m) Library Contents Sufficient for the Route
n) All revenue payload removed.

**PERFORMANCE:**

CARD Input……..

**PERFORMANCE – WEIGHT REDUCTION**

(Only if performance is critical)

GALLEY EQUIPMENT……...?
POTABLE WATER……?
TOILET TANKS……..?
FAN BLADES……?

**FLIGHT PLANNING**

CIRRUS based on LRC speeds same as FMC with one engine inoperative.

**CROSSWINDS**

Wind speed >65K shaded

| **Comp→** | **7** | **15** | **25** | **30** |
|---|---|---|---|---|
| **Angle↓** | Max | Wind | Speed | |
| 10° | 40 | 86 | >100 | >100 |
| 20° | 20 | 43 | 73 | 88 |
| 30° | 14 | 30 | 50 | 60 |
| 40° | 11 | 23 | 38 | 47 |
| 50° | 9 | 19 | 32 | 39 |
| 60° | 8 | 17 | 28 | 35 |
| 70° | 7 | 16 | 26 | 32 |
| 80° | 7 | 15 | 25 | 30 |
| 90° | 7 | 15 | 25 | 30 |

**VMCG (TO2)**

OAT °C

| **P.A** | **30** | **35** | **40** | **45** | **50** |
|---|---|---|---|---|---|
| -2000 | 113 | 113 | 111 | 108 | 106 |
| 0 | 111 | 109 | 107 | 105 | 103 |
| 2000 | 107 | 106 | 104 | 101 | 99 |
| 4000 | 103 | 102 | 100 | 97 | |
| 6000 | 100 | 98 | 96 | | |
| 8000 | 96 | 95 | 93 | | |
| 10000 | 93 | 91 | | | |