Part III

Chapter 1—Engine Starting and Handling

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1 General

Throughout, it should be remembered that the relevant checks must be carried out.

2 Normal start

(a) Starting—air supplies

Air supplies for starting the engines should normally be obtained from either the AAPP or the combustor. If the AAPP is unserviceable the aircraft should not be flown. If for any reason it is desired not to use the AAPP, air supplies may be obtained from a Ground Air Supply Unit (Palouste). The air hose for this supply should be connected to the coupling behind a panel in the starboard inner engine door. Either the AAPP or the ground air supply may be used to start any engine, the air CROSSFEED COCK must be opened to allow No. 1 or No. 2 engine to be started. Also, when necessary, the air supplies of any one or more running engines can be used to start the remaining engines. The recommended starting order is 4, 3, 2, 1.

(b) Starting the AAPP

Before starting carry out the following checks:

(i) Check that the ground area is clear for starting and the AAPP shut-off cock is closed.

(ii) Ensure that an internal 24-volt LV supply, or external 28-volt supply is available.

(iii) INTAKE SELECTION switch	Test OPEN and RETRACT operation and indications Leave OPEN
(iv) Fire warning	Test
(v) LOAD SELECTION switch	IDLE
(vi) START SELECTION switch	NORMAL

The AAPP will start automatically. During the start check:

(vii) START IN PROGRESS light	On, then out at 6,000 — 8,000 RPM
(viii) Fire warning light	Out
(ix) OIL PRESSURE light	On
(x) JPT	Not above 700°C

The RPM should increase and idle at 23,000—25,000 RPM. If the AAPP is required for engine starting only, leave LOAD SELECTION switch at IDLE. If the AAPP is required for electrical supplies also, select LOAD SELECTION switch to ELECT, check that engine speed increases to 33,200—35,200 RPM and that the JPT does not exceed 515°C. If, during starting, the AAPP fails to light, or if the JPT exceeds 700°C select the START SELECTION switch to OFF. The max. JPT during air delivery for main engine starting is 585°C for one minute.

(*c*) *Engine start using* AAPP *air supply*

(i) Before starting each engine, check with the crew chief that the ground area is clear. Start No. 4 engine first. Check:

Fuselage booster pumps	ON
Fuselage Proportioner switch	BYPASS
LP cocks	OPEN
EGT isolation switches	NORMAL
EGT controller switch	TAKE-OFF
Throttle levers	HP cock closed
Engine bleed isolation cocks	OPEN
Ignition isolation switch	ON
Air crossfeed cock	OPEN
Start master switch	AAPP
Engine selector switches	No. 4 ON
Start button	PRESS until No. 4 START IN PROGRESS light illuminates

(*d*) When the light illuminates, release the gate mechanism and open No. 4 throttle to the IDLING position (just beyond the gate). Engine light up should occur in 8 to 10 secs. after opening the HP cock. During the start check:

Fire warning light	Out
Oil pressure	Registering (12 PSI min. at ground idle RPM)
EGT	Not above 600°C

When the engines reaches 38% RPM the engine starter button should spring out and the START IN PROGRESS light extinguish. The engine should accelerate to a ground idling speed of approximately 48% RPM. If the starter button has not released when 38% RPM is reached, move the STARTER MASTER switch to FLIGHT and back to AAPP. If, during the start, the EGT exceeds 600°C, close the HP cock immediately and monitor the fire warning light.

(*e*) After starting No. 4 engine, return the No. 4 selector switch to OFF. Start Nos. 3, 2, and 1 engines, using the same procedure.

(*f*) When all engines have been started, check:

Air crossfeed cock	CLOSED
Starter master switch	FLIGHT
Ignition isolation switch	ISOLATE
Alternator switches	ON

3 Rapid start

(*a*) This paragraph deals only with engine starting using the wing mounted air bottle supplies and combustor starters. To gain full benefit from the rapid start the Rapid Take-Off check list should be followed. A combustor start must not be attempted at air temperatures below −15°C. To start a pair of engines the minimum air bottle pressure on the appropriate side is 2,900 PSI (1,500 PSI is sufficient to start one engine of a pair). Should an engine fail to start a 30 min. period must elapse before attempting a second *combustor* start.

(*b*) *Engine starting using combustor starters*

(i) Before starting the engines check with the crew chief that the ground area is clear. Check:

Fuselage booster pumps	ON
Fuselage proportioner switch	BYPASS
LP cocks	OPEN
EGT isolation switches	NORMAL
EGT controller switch	TAKE OFF

Throttle levers . . .	OPEN
Engine bleed isolation cocks .	OPEN
Ignition isolation switch .	ON
Start master switch . .	COMBUSTOR
Engine start selector switches	ALL ON
Air crossfeed cock . . .	OPEN

Press the starter button, check that four START IN PROGRESS lights illuminate and keep a careful watch on EGT's. The engines should reach self-sustaining speed in approximately 11 seconds and the starting cycle terminated by the operation of an engine speed sensitive switch. If an engine fails to start, the starting cycle is terminated by a time switch after 15 seconds. Should the EGT exceed 600°C (690°C operational) or should the rate of rise of EGT indicate that 600°C (690°C) is likely to be exceeded, the throttle lever must be closed to the HP shut-off position immediately. EGT should normally fall below 600°C but if 690°C is reached a fault in the system is indicated.

(ii) If an engine fails to start there may be insufficient air pressure remaining to attempt a second combustor start after 30 minutes. With the air crossfeed cock and engine bleed valves open, however, the fastest restart will be obtained by using the air supplies of the running engines. Check:

Running engines . . .	Accelerating through 40% RPM
Throttle lever of affected engine	Closed to idling gate
Start master switch . .	GROUND
Engine selector switches . .	Failed engine ON, others OFF

Press the starter button until the START IN PROGRESS light illuminates and monitor EGT carefully.

(iii) When all engines have started check:

Air crossfeed cock . .	CLOSED
Starter master switch . .	FLIGHT
Ignition isolation switch . .	ISOLATE
Engine selector switches .	OFF

NOTE: Should it not be intended to carry out a scramble take-off, the throttles may be closed to the idling gate when the engines reach normal idling speed.

4 Ground handling

The ground idling speed should be 48% RPM, the maximum EGT at idling is 430°C and the minimum oil pressure 12 PSI.

5 Engine handling in flight

(*a*) Throughout flight the engine limitations must be observed. If at any time the EGT limitations are exceeded the throttle must be retarded to maintain the EGT within limits. This is particularly important above 50,000 feet and the EGT must be monitored closely. Any instance of the limitations being exceeded must be recorded and reported.

(*b*) At high altitudes, to prevent surge and flame-out, the throttles should be handled gently at all times, although rapid accelerations and decelerations are permissible in cases of necessity provided that, above 45,000 feet, the inboard engines are maintained at 90% RPM or more. To reduce the possibility of surge or flame-out at very high altitudes (above 55,000 feet), if it is necessary to re-accelerate the engines after the throttles have been closed, ensure that the RPM and EGT are stabilised at flight idling before re-opening the throttles.

(*c*) *Use of the* EGT *controller*

The EGT isolation switches should be selected to NORMAL under all normal flight conditions, and the EGT controller switch should be selected to TAKE-OFF, CLIMB or CRUISE as required. The EGT controller must not be used to reduce engine power at low altitude. When selecting a lower EGT controller setting, close the throttles until all engines are slightly below the appropriate EGT, select the EGT controller switch as required and then open the throttles fully. When selecting a higher EGT controller setting, make the appropriate selection and then open the throttles as required. If an engine fails to accelerate to the EGT appropriate to the EGT controller switch selection, close the throttle until a reduction in EGT

is indicated, select the appropriate EGT isolation switch to ISOLATE, and advance the throttle carefully. If the required EGT can now be obtained, a EGT controller fault is indicated; the isolation switch should be left at ISOLATE and the EGT maintained within limits by careful use of the throttle. Great care must be taken with the switch at ISOLATE, particularly at high altitudes, as the LP overspeed governor is also isolated.

(*d*) LP *compressor overspeed*

If any LP compressor overspeed warning light illuminates the appropriate throttle must be retarded until the warning light goes out. Subsequent throttle opening must be made slowly.

6 Stopping an engine in flight

To stop an engine in flight, or if an engine fails, close the throttle and bring it back through the gate to shut off the HP cock. The alternator must be switched OFF. The LP cock must only be closed if the engine actually stops turning or if there is a risk of fire.

7 Relighting in flight

(*a*) *Hot relighting*

An engine flame-out can generally be recognised by falling RPM. A hot relight can normally be obtained under any flight conditions (possibly up to 55,000 feet) if the following action is taken soon after the flame-out occurs and before the RPM fall below the flight idling values:

(i) *Below* 35,000 *feet*

Press the relight button without moving the throttle until a relight is obtained; this is recognised by the RPM ceasing to fall. If a relight is not obtained immediately, progressively close the throttle to the idling gate as the RPM continue to fall. If a relight is obtained after a large drop in RPM has occurred, it may be difficult to accelerate the engine and surging may occur. In this case, keep the relight button pressed and advance the throttle to accelerate beyond the surge.

(ii) *Above* 35,000 *feet*

Press the relight button and, at the same time, close the throttle to the idling gate. When a relight is obtained, recognised by the RPM and EGT stabilising at the flight idling value, allow 30 to 60 seconds to elapse before opening the throttle to set the required RPM. This procedure provides the best chance of achieving a relight without surge occurring at high altitudes. At very high altitudes, to prevent any surging affecting the adjacent engine, its relight button should be pressed during the hot relight, to reduce the possibility of a sympathetic flame-out.

(iii) *High* JPT

During a hot relight, keep a careful watch on the EGT. If, at any time, the EGT approaches the limit or rises without a corresponding increase of RPM, shut the HP cock immediately.

(iv) *Failure to relight*

If a relight is not obtained within 20 seconds of pressing the relight button, close the HP cock and wait at least 1 minute before attempting a cold relight.

(*b*) *Cold relighting*

NOTE 1: No oil pressure indication will be obtained until the bus-bar supplying the associated engine is energised.

NOTE 2: A cold relight can reasonably be expected up to 40,000 feet at any airspeed, but the band 210 to 240 knots is recommended; if a relight is unsuccessful descend to 35,000 feet or below before making any further attempt.

Ensure that a fuel supply is available to the engine. Press the relight button and open the HP cock. When the RPM or EGT start to increase release the relight button and, when the engine is running satisfactorily, open up to the desired RPM. Under normal conditions a relight should be obtained within 15 seconds. If an engine fails to relight within 20 seconds, close the HP cock and wait one minute before making a further attempt.

8 Low oil pressure

The normal oil pressure is 40 PSI at 90% RPM and above and the minimum oil pressure is 28 PSI at 80% RPM and above. If the oil pressure falls below the minimum pressure, the engine should be stopped as soon as possible. However, if emergency conditions exist which would be made more hazardous by closing down the engine, the minimum oil pressures for continual use of the engine until the earliest possible landing are 24 PSI at 86% RPM and *pro-rata* to 28 PSI at 99% RPM.

9 In-flight starting of the AAPP

In-flight starting of the AAPP is described under Management of the Electrical System, Part I, Chap. 1, para. 24.

10 Stopping the engines

Carry out the closing down checks in the Flight Reference Cards and stop the engines by closing the HP cocks. Do not close the LP cocks or switch off the special feeder switches until the engines are below 10%.