Part IV

Chapter 1—Engine Starting and Handling

List of Contents

1 General

Throughout it must be remembered that the relevant checks in Part III must be carried out at the appropriate times.

2 Starting the engines using an external power supply

(*a*) The recommended starting order is 3 —2 — 1 — 4.

(*b*) The following selections and checks must be made before engine starting:

External electrical supply	112v and 28v DC connected and ON
LV batteries	ON
MV batteries	OFF
Inverters	No. 3 ON, No. 2 OFF, No. 1 as required
Alternators	OFF
No. 1 Flight instruments circuit breaker	Made
Fuel proportioners	All NORMAL
Fuselage booster pumps	All on
LP cocks	OPEN
JPT control switches	OFF
IGNITION and MOTOR ISOLATION switches	ON
ENGINE SELECTOR	No. 3
START MASTER switch	GROUND

(*c*) Open the HP cock to the idling position (just beyond the gate) and press the STARTER PUSH button. The STARTER PUSH button should lock in until released by the overspeed relay (or on completion of the starting cycle after 30 seconds) and the AEO may monitor the stages of the starting cycle by watching for movements of the MV voltmeter needles. Engine light-up will be indicated by increasing RPM and JPT. When the spill-valve closes at 22% RPM a sharp increase in JPT may be noticed. During the start the JPT may rise above the idling limit of 660°C and, if it

rises to 875°C (800°C on unmodified gauges) before engine speed reaches 18·5% RPM, the HP cock must be closed immediately. If the engine is still accelerating at 18·5% RPM with the JPT below 800°C the start may be continued, even though the JPT rises to 875°C (800°C on unmodified gauges) later in the starting cycle. The JPT should be below 660°C when the engine reaches idling speed (37·5 ± 2·5% RPM). If, during the start, the JPT exceeds 875° or, if the fire warning light illuminates, close the HP cock immediately.

(*d*) When the engine reaches idling speed check:

Engine fire warning lights	Out
JPT	660° C maximum
Oil pressure	8 PSI minimum

NOTE: The oil pressure may take several seconds to build up, especially if the engine has not been run for some time. If the oil pressure fails to build up within 30 seconds of initiating the start, stop the engine and carry out a dry motoring cycle. If the oil pressure fails to build up a second time, the fault must be investigated.

(*e*) Start the remaining engines in a similar manner and, when all engines are running, put the START MASTER switch to FLIGHT, switch OFF the IGNITION and MOTOR ISOLATION switches and complete the after-starting checks.

(*f*) *Precautions*

The STARTER PUSH button must not be held in manually if it fails to be retained electrically after it has been pressed and has held momentarily. Failure to observe this precaution may result in damage to the starter drive mechanism.

3 Starting when external power supply is available for starting only one engine

Start No. 3 (or No. 4) engine in the normal manner. When it is running satisfactorily switch ON its alternator and switch on the MV and LV batteries. Disconnect the ground supply and increase the engine speed to 75% RPM. Subsequent engines may then be started in the manner laid down for starting on internal power.

4 Starting on internal power

(*a*) When it is necessary to use the aircraft internal batteries for starting engines, use of electrical services should be limited to those essential for engine starting and for the aircraft's safety, until all engines are running and their alternators switched on.

(*b*) No. 3 (or No. 4) engine should be started first.

When it is running satisfactorily, its alternator should be switched ON and engine speed increased to ensure that alternator output is sufficient for starting the remaining engines. Because of the airflow patterns in the combined engine intakes the engines on the opposite (port) side of the aircraft must be started next, the adjacent engine on the starboard side being started only when the first engine has been brought back to idling RPM.

(*c*) Make the following selections and checks:

All alternator switches	OFF
Flight instrument circuit breakers	Made
Port and starboard special feeders	ON
LV batteries	ON
LV BUSBAR PARALLELING switch	EMERGENCY (ON) Indicator white
Intercomm. switches	ON
Engine fire warning system	Test
HYDRAULIC WARNING	Out
Brake pressures	2000 PSI minimum
Undercarriage indicator	3 green lights
MV batteries	ON
Fuel proportioners	BYPASS

Booster pumps	One fuselage pump on
LP cocks	No. 3 OPEN, LP fuel warning light out
IGNITION and MOTOR ISOLATION switches	ON
ENGINE SELECTOR	No. 3
START MASTER switch	INTERNAL
No. 3 type 350 inverter	ON
MV PARALLELING indicator	White

Open No. 3 HP cock to the idling position and press the STARTER PUSH button.

(*d*) When No. 3 engine reaches idling RPM check :—

Alternator circuit breakers	All made
No. 3 alternator	ON, light out, output normal
Cooling fan warning lights	Out
Fuselage booster pumps	All on
Fuselage proportioner	NORMAL
LP cocks	All OPEN

Increase No. 3 engine speed to 75% RPM, open Nos. 1 and 2 HP cocks and start Nos. 1 and 2 engines in turn.

(*e*) When Nos. 1 and 2 engines are started, switch ON their alternators and check that output is normal. Increase Nos. 1 and 2 engine speeds to 75% RPM and throttle back No. 3 engine to idling RPM. Open No. 4 HP cock, start No. 4 engine and, when at idling speed, switch ON No. 4 alternator. Throttle back all engines to idling RPM and check:—

IGNITION and MOTOR ISOLATION SWITCHES	OFF
START MASTER switch	FLIGHT
MV PARALLELING indicator	Black
LV BUSBAR PARALLELING switch	NORMAL (OFF)
LV PARALLELING indicator	Black

Complete checks and selections as required.

5 Failure to start

(*a*) If an engine fails to light-up, the HP cock must be closed immediately. The engine must be allowed to come to rest and may then be motored over to clear excess fuel before the next attempt to start. If the surrounding ground becomes soaked with fuel the aircraft must be moved before attempting a restart.

(*b*) After three consecutive operations of the starter motor, wait 15 minutes for cooling before using the starter again. This allows only two attempts to start, with a dry motoring cycle in between.

(*c*) Following a failure to start or a dry motoring cycle, ensure that the engine has come to rest before the STARTER PUSH button is pressed again.

6 Dry motoring cycle

The procedure for a dry motoring cycle is similar to a normal start except that the IGNITION ISOLATION switch is left OFF and the HP cock is left CLOSED. The STARTER PUSH button will release after 30 seconds, and engine speed should reach at least 10.5% RPM.

7 Engine handling

(*a*) At all times the engine handling limitations must be observed. Any instance of the limitations being exceeded must be reported.

(*b*) The throttles may be opened or closed rapidly under any flight conditions but, except in emergency, more gentle handling of the throttles is recommended.

(*c*) *Running a single engine above* 52·5% RPM

When running any engine above 52·5% RPM the speed of the other engine on the same side should be increased to a minimum of 52.5%. This is necessary because the engine being run at high

speed will partially starve the other engine of air if it is left at idling speed. This will result in a decrease in speed on the idling engine and an excessive rise in JPT ; the engine may flame out and an engine fire result.

(*d*) *Take-off and climb*

(i) If the initial climb to 20,000 feet is made at full power, engine speed may increase to 100.5% RPM but, above this height, a negative creep device gradually reduces engine speed with height to maintain the JPT within limits. As a result, full throttle engine speed at 45,000 feet will be about 97.5% RPM. However, irrespective of the engine speed obtained at full throttle, the throttle settings must be reduced to intermediate power within 10 minutes of take-off.

(ii) Without automatic jet pipe temperature control, when climbing at engine speeds above 93% RPM but below full power, it is necessary to adjust the throttle settings to maintain the selected engine speed or to keep the JPT within limits.

(iii) When the 3-datum automatic jet pipe temperature control is fitted, the throttles may be left in the fully open position after take-off and, with the JPT isolation switches ON, the selected JPT, as determined by the JPT controller, is maintained at all altitudes with corresponding changes in engine speed.

NOTE: Failure or isolation of the JPT controller on an engine whilst CRUISE or CLIMB is selected, will result in a slow rise in engine speed and JPT. In this case, control the engine speed and JPT by normal throttle manipulation.

8 Use of the engines anti-icing system

(*a*) The system should be brought into use during the pre-take-off checks when the OAT is below +3°C and the relative humidity exceeds 90% or the visibility is less than 1,000 yards in fog or mist. Reference is to be made to the Operating Data Manual for take-off performance corrections. The system may be used for take-off and during all conditions of flight when icing conditions are encountered.

(*b*) When the system is in use the available take-off thrust varies with OAT. The following are the relative figures, expressed as a percentage of ISA take-off thrust:

+ 5°C	94·5%
0°C	97%
− 5°C	99·5%
−10°C	102%
−20°C	107%

(*c*) The use of the anti-icing system causes the JPT to rise by approximately 25° to 30°C, if the system is fully OPEN and by approximately half that figure if the HALF-OPEN position is selected. If automatic JPT control is not fitted it may be necessary to reduce the throttle setting to avoid exceeding the max. permissible JPT. Where automatic JPT control is fitted, engine speed will be reduced automatically.

NOTE: HALF-OPEN should be selected whenever the engine speed is above 82%. OPEN should be selected at engine speeds below 82%.

9 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 be closed only if the engine actually stops turning or if there is a risk of fire.

10 Relighting in flight

(*a*) Relighting is progressively more certain with decrease in altitude and the chances of a successful relight are greater if the engine is warm.

(*b*) If an engine flames out for reasons other than mechanical failure or deliberate shut-down, a relight may be attempted immediately, while engine speed is decreasing, by pressing the relight button with the throttle at its set position. A successful

relight will be indicated by the engine speed stabilising and then commencing to rise. The likelihood of a successful relight is reduced if height is above 40,000 feet.

(*c*) For relighting a cold engine the following procedure should be used:

(i) Adjust airspeed until the failed engine is windmilling at 23·2% RPM—the optimum windmilling speed for relighting. The minimum windmilling RPM for a successful relight varies from 11·5% at 10,000 feet to 17·5% at 35,000 feet. Above 36,000 feet it is necessary to maintain a windmilling RPM as near to 17·5% as the minimum flight speed will permit.

(ii) Check the following:

Booster pumps . . .	ON
LP cock	OPEN
Starter master switch . .	FLIGHT

(iii) With the HP cock shut, press and hold the relight button. After 3 seconds release the HP cock gate and move the throttle on to the IDLING stop, continuing to press the relight button. When the engine speed has increased by 3%, release the relight button. If the JPT rises to 66°C and continues to rise, the HP cock should be closed immediately. This action should also be taken if the engine has not lit within 15 seconds of initially pressing the relight button.

(iv) After an abortive relight attempt, the engine and jet pipe must be drained of unburned fuel over a period of three minutes before a further relight is attempted. If circumstances permit, the second attempt to relight should be made at a lower altitude after checking the igniter fuse. Not more than three unsuccessful attempts to relight should be made on any one engine in one sortie. One of the attempts should be made using the other relight button.

(v) If time permits, all unnecessary electrical loads should be taken off the affected bus-bar before the relight button is pressed. The alternator should be switched ON when the RPM have stabilised. As soon as the voltage and current is stable, the normal loads may again be placed on the bus-bar.

11 Stopping the engines

When all MV electrical loads have been switched off, switch OFF the alternators and stop the engines by closing the HP cocks. Do not close the LP cocks or switch off the special feeders until the engines have stopped rotating.