Part III—Engine and Aircraft Handling

Chapter 1—Starting, Taxying and Take-Off

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1 General

Throughout, it must be remembered that the relevant checks in the Flight Reference Cards must be carried out at the appropriate times.

2 Starting the engines using an external 112V power supply

(*a*) When starting with an external 112V power supply, the engines may be started in any order, but it is usual to start No. 1 first. Confirm with the Crew Chief that it is clear to start engines. Having selected the correct engine on the ENGINE STARTING selector switch, press the starter button for two seconds. The starter button should lock in until released by the overspeed relay after about 22 seconds. As the oil pressure begins to rise, indicating that the engine is turning, move the throttle slowly towards the IDLING position. A correct start will be indicated by rising RPM and JPT. During a start the JPT may rise to about 400°C, and then fall to about 250°C. The RPM should stabilise at the idling speed but it may be necessary to accelerate the engine slightly to achieve the correct idling speed.

On completion of the checks after starting each engine, the remaining engines may be started in turn by making the appropriate selection on the ENGINE STARTING selector and repeating the procedure described above.

(*b*) *Checks after starting each engine*

Fire warning light	Out
JPT	Below 600°C (but normally about 250°C)
Oil pressure	Registering
RPM	31½—32½%
Starter button	Out

(*c*) *Precautions*

(i) If the JPT rises to 600°C or above, close the HP cock immediately, and isolate the starter motor by switching off the starter master switch.

(ii) The ignition isolation switch must not be made, nor may the relight button be pressed, once the starting cycle has commenced.

(iii) If the starter button does not remain in when it is depressed, no further attempt to start is to be made and engines already running must be shut down. The external or internal power must then be switched off and the starter panel in the power compartment inspected for fire or overheating at the engine start relays.

(d) Failure to start

If an engine fails to start, move the throttle lever to the HP COCK SHUT position immediately. Allow the engine to come to rest and then clear out the excess fuel by means of a dry motoring cycle.

3 Dry motoring cycle

The procedure for a dry motoring cycle is similar to a normal start, except that the ignition isolating switch is OFF, and the HP cock remains closed. After the engine has been cycled, allow it to stop rotating before again pressing the starter button.

4 Starting the engines using the internal batteries

(a) General

The internal batteries should only be used for starting engines when an external 112V supply is unobtainable. No. 1 or No. 2 engine must always be started first. Nos. 3 and 4 engines cannot be used for supplying power for engine starting. Check that the 24V battery voltage exceeds 22V, and that the 96V battery voltage exceeds 88V (92V, Type K) under nominal load, otherwise there will be a risk that the batteries will overheat when they subsequently come on charge.

(b) Starting the first engine

Ensure that the area to the rear of the aircraft is clear and that all 112-volt and 28-volt services, except those mentioned below, are switched off.

Carry out the following additional checks: —

Generator control switches	OFF & TRIM
Rotary transformers	OFF
28-volt isolating switch	ON. Check battery volts
112-volt isolating switch	ON. Check battery volts
Inverters	All OFF
LP cocks	ON
Booster-pumps	No. 2. No. 2 group ON
Throttle lever	HP cock SHUT
ENGINE MASTER switch	ON
IGNITION ISOLATION switch	ON
ENGINE STARTING selector	No. 2

Then start the No. 2 engine as in para 2. When the engine has started, check that the voltage of the No. 2 generator is between 109 and 115 volts. Switch ON No. 2 generator and press the No. 2 ENGAGE button. Check that the generator failure warning light goes out.

(c) Subsequent engines

Open up the No. 2 engine to at least 65% RPM for three minutes before the next engine is started. Maintain this engine speed during the starting cycle of the second engine keeping a careful watch on the 112-volt bus-bar voltmeter to ensure that the No. 2 generator is not overloaded.

Then check: —

No. 1 rotary transformer	ON
No. 1 inverter	ON
Booster-pumps	No. 1. No. 1 group ON
ENGINE STARTING selector	No. 1
Throttle lever	HP cock SHUT

Start the No. 1 engine and bring its generator on line as in *(b)* above.

When the No. 1 engine has started, open up both Nos. 1 and 2 engines to at least 65% RPM, and repeat the starting drill for Nos. 4 and 3 engines. These engines are to be started in the order No. 4 and then No. 3. As each engine is started and running correctly, bring its respective generator on line. This action relieves part of the load of Nos. 1 and 2 generator bus-bar when starting No. 3 engine. When all engines are running and all generators are on line, switch ON all booster-pumps.

5 Taxying

(*a*) As visibility from the cockpit is restricted, it is advisable to inspect the area before entering the aircraft, especially if it is intended to taxy in confined spaces. Particular note should be taken of objects likely to be blown by the jet efflux.

(*b*) Before taxying, the relevant checks must be carried out, and the scanner stabilised or secured.

(*c*) The thrust required to overcome the inertia of the aircraft and tyre set, varies with the AUW and surface, but large amounts of thrust are rarely needed. Once the aircraft is in motion, sufficient thrust for normal taxying is obtained with all engines idling. At light weights, it will be found difficult to keep the speed down with all engines running. It is recommended therefore, that on completion of a sortie, the outboard engines are shut down to reduce the brake load.

(*d*) As soon as convenient after moving, the brakes and nosewheel steering should be checked. To operate the nosewheel steering, press the selector button at the base of the control handle and off-set the rudder by the required amount. Very little is achieved by using asymmetric thrust in turns. Differential braking, however, can be used to assist in tight turns, but care should be taken not to turn too tightly by this method, otherwise the steering and centring jacks may be damaged. It is possible to complete a 180 degree turn fairly comfortably on a 50-yard runway. When taxying at heavy weights, sharp or fast turns must be avoided.

(*e*) (i) In emergency, it is possible to taxy using differential braking only to turn ; the pilot should always be ready to steer by this method should the nosewheel steering fail.

(ii) The bomb-doors should not be operated while taxying, as the nosewheel steering becomes ineffective until their operation has ceased (approx. 6 seconds).

(iii) The brakes are very effective but it is possible to use them unevenly and thus to overheat one side by inadvertent differential braking, when taxying or during the landing run.

6 Take-off

(*a*) Complete the checks before take-off before entering the runway. Align the aircraft with the runway, and with the brakes applied, open the throttles to 80% RPM, making sure that the brakes hold. Ensure that the parking brake is off, oil pressures and JPT's are correct and, when the engines are stabilised, release the brakes gently and then open the throttles to full thrust. If the brakes are released suddenly, the nose tends to rise but it is unlikely that the nosewheel will leave the runway. If, in an emergency, the JPT limiters are over-ridden, the RPM must be restricted during take-off (according to the table below) in order to avoid exceeding the JPT limits.

Ambient temp. °C	15	20	25	30	35	40	45
Take-off engine speed limit	99·5%	99%	98·5%	98%	98%	97·5%	97%

(*b*) There is no tendency to swing and any small deviations in the early stages can be corrected by nose-wheel steering. The rudder is effective above 60 knots. Acceleration is rapid and take-off speed is achieved in 30 seconds, even at high weights. (but see Operating Data).

(*c*) The nose-wheel should be kept on the ground and the slight tendency for the nose-wheel to rise at about 100 knots, depending on AUW, checked with a forward pressure on the control column until 10 knots before unstick speed (see Operating Data), when the nose-wheel should be lifted gently off the runway, and at the unstick speed, the aircraft lifted off the ground. The following speeds are recommended: —

Take-off weight (*lb*)	*Unstick speed* (*knots*)
120,000	120
130,000	125
140,000	130
150,000	135
160,000	140
170,000	145
180,000	145
190,000	150

(*d*) In cold damp weather (+3°C or below and 90% or more humidity or visibility less than 1,000 yards), immediately before take-off, run the engines at 60% RPM or more for one minute with PORT and STBD, WING and ENGINE anti-icing switches to AUTO. Take-off with anti-icing at AUTO.

7 After take-off

(*a*) When the aircraft is safely off the ground, apply the brakes and select undercarriage UP. There is no appreciable trim change during take-off or undercarriage retraction, but as speed increases, a steadily increasing push-force on the control column is necessary, because of the rapid increase in speed. This push-force can be trimmed out easily, in increments, as the aircraft is accelerated to its climbing speed. The undercarriage retracts in 9-10 seconds and no difficulty is experienced in achieving a clean aircraft before the undercarriage limiting speed of 220 knots is reached. Whenever possible, the undercarriage should be completely retracted before exceeding 200 knots.

(*b*) At a safe height throttle the engines to reduce JPT to 615°C or below, and select CRUISE on the T/O/CRUISE selector and then open the throttles fully. Carry out the after-take-off checks before reaching 5,000 feet. Make a visual inspection of the undercarriage, after UP selection, using the periscope.

(*c*) During the take-off, any malfunction of the yaw damper does not noticeably affect handling characteristics, but as speed increases to about 170 knots, the effects become apparent. In the event of a malfunction, switch OFF.

8 Safety speeds

If an engine failure occurs, the tendency to swing is easily controlled with rudder, and the safety speed will always be below the unstick speed. The decision whether to continue or abandon take-off will depend upon the results of previous calculations (See Operating Data).

9 Double engine failure during take-off

(To be issued by amendment.)

10 Accelerated stop procedure

After an abandoned take-off it is essential that the brakes are examined before a further attempt to take-off is made.

11 Climbing

(*a*) The aircraft should be climbed at MAX CONTINUOUS RPM at 250 knots up to 20,000 feet, and then at 300 knots up to a height where this speed coincides with 0·88M.

(*b*) If the JPT limiters have been over-ridden, because of unserviceability, the JPT's must be watched very carefully if the limits are not to be exceeded during the climb.

(*c*) The best cruise climbing speed is 0·88M (but see Operating Data). Under conditions where range is critical it is best to cross-check the machmeter against TAS.

12 Cabin conditioning during the climb and descent

The following procedure has been introduced to protect the hot air ducting from excess pressures: —

(*a*) Engine and cabin air valves are to be SHUT until the take-off checks, when both cabin air valves only are to be set to OPEN.

(*b*) During the after-take-off checks, the No. 2 engine air valve only is to be opened.

(*c*) At 10,000 feet and above, No. 4 engine air valve is to be set OPEN.

(*d*) At altitude all engine air valves OPEN (above 40,000 feet).

(*e*) During descent, shut Nos. 1 and 3 engine air valves at 40,000 feet and No. 4 at 10,000 feet.

(*f*) It is emphasised that the cabin air valves are not to be SHUT while the engine air valves are OPEN.