

Chapter 5

ENGINE STARTING AND GROUND CHECKS

WARNING...

Before leaning into, or entering, the cockpit, refer to the LETHAL WARNING card at the beginning of this book.

PRECAUTIONS

1.

(1) This aircraft has an ejection seat and other potentially lethal equipment.

(2) Place the aircraft, as nearly as possible, nose into wind and so that there is a distance of at least 100 yards between the engine exhausts and the nearest aircraft or building.

(3) Ensure, by inspection, that the ground within a radius of 10 yards of the nose of the aircraft is free from loose articles and debris.

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(4) Apply the parking brake and check that the brake pressure gauge (parking) reads not less than 2000 lb/in². Chock the wheels. Fit the undercarriage safety locks if they are available.

(5) Check, by inspection, that no blanks or covers (other than the pressure-head cover) are fitted, that the air intake is both clear and clean, and that all access panels other than any removed for ground-running purposes (*para.6*) are properly secured.

(6) All personnel to be engaged in the operation must be instructed regarding loose head-gear and pocket contents, the avoidance of air-intake and jet-efflux danger areas (*fig.1*), and the interpretations of hand and other signals to be used for communication (the external inter-comm. system may be used for the latter purpose if the necessary equipment is available).

(7) Station a look-out, instructed to prevent entry into danger area of personnel and vehicles, in such a position that he is, and remains, within sight of the occupant of the cockpit.

Note...

Seven circular fire break-in panels, coloured red, give access to the engine bays from the starboard side of the fuselage. They are spring-loaded and easily displaced by the nozzle of fire-fighting equipment.

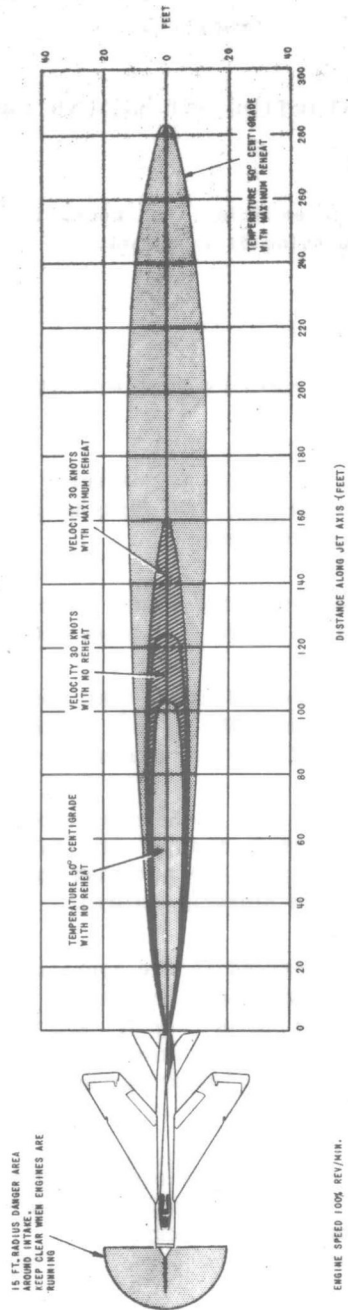


Fig. 1. Jet efflux danger area

SETTING THE CONTROLS: PRELIMINARY CHECKS

2.

(1) Check the levels of the engine oil and the hydraulic fluid reservoir (Chap.4). Check the starter system fuel tank content, also that of the fuel tanks. Remove the pressure-head covers. Connect a.c. and d.c. ground electrical supplies.

(2) Set and check the cockpit controls and indicators:-

| | |
|--|-------------------|
| Engine throttle controls | H.P. COCKS OFF |
| Throttle servo clutch | DISENGAGED |
| Jet-pipe temperature control switches | AUTO |
| Battery switch | ON |
| Engine start master switch | ON |
| Instrument master switch | ON |
| Rain dispersal/de-icing switch | OFF |
| Standard warning system indicator unit | 'T' button (test) |
| | 'M' button down |
| Auxiliary warnings indicator panel | Test |
| Fuel transfer switch | Central position |
| Generator switch | NORMAL |
| M.R.G. switch | OFF (pulled out) |

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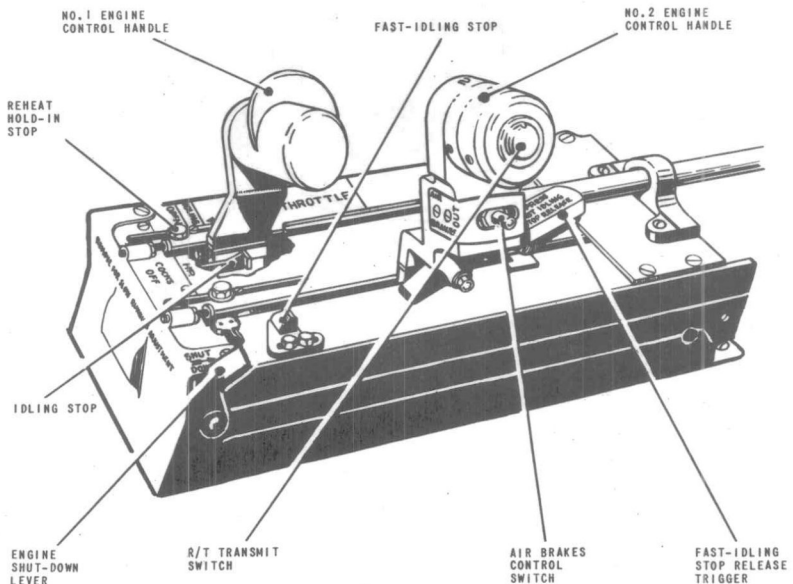


Fig. 2. Throttle control unit

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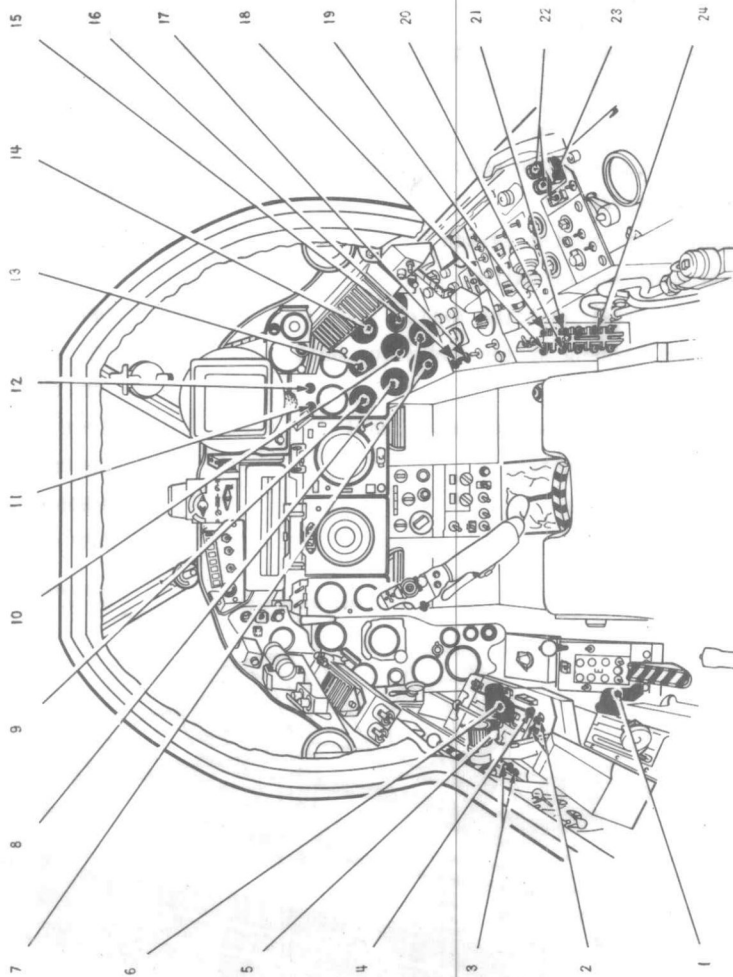


Fig.3. Engine controls and instruments

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KEY TO FIG. 3 (ENGINE CONTROLS AND INSTRUMENTS)

- 1 THROTTLE SERVO CLUTCH HANDLE
- 2 RELIGHT PUSH SWITCHES
- 3 JET-PIPE TEMPERATURE CONTROL SWITCHES
- 4 SHUT-DOWN LEVER
- 5 CONTROL HANDLE (NO. 1 ENGINE)
- 6 CONTROL HANDLE (NO. 2 ENGINE)
- 7 JET-PIPE TEMPERATURE GAUGES
- 8 SPEED INDICATOR (NO. 1 ENGINE)
- 9 FUEL CONTENTS GAUGE - MAIN TANK (PORT)
- 10 SPEED INDICATOR (NO. 2 ENGINE)
- 11 FUEL TRANSFER INDICATOR (WING-TO-WING)
- 12 FUEL TRANSFER SWITCH (WING-TO-WING)
- 13 FUEL CONTENTS GAUGE - MAIN TANK (STARBOARD)
- 14 FUEL CONTENTS GAUGE - VENTRAL PACK
- 15 JET-PIPE NOZZLE INDICATORS
- 16 FUEL CONTENTS PUSH-SWITCH - FLAP TANKS
- 17 FUEL CONTENTS GAUGES TEST SWITCH
- 18 FUEL COCK SWITCH - PORT
- 19 FUEL COCK SWITCH - STARBOARD
- 20 FUEL D.C. PUMP SWITCH - PORT
- 21 FUEL D.C. PUMP SWITCH - STARBOARD
- 22 START PUSH-SWITCHES
- 23 IGNITION SWITCHES
- 24 ENGINE MASTER SWITCH

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STARTING THE ENGINES

3.

(1) Set:-

| | |
|--|----|
| Fuel pump switches | ON |
| Fuel cock switches | ON |
| Engine ignition switches (these switches are normally locked on) | ON |

(2) Move No. 2 engine control to IDLING and, without delay, press No. 2 engine starter button for 2 seconds and release it. Engine 'light-up' occurs within 4-8 seconds and the jet-pipe temperature at once starts to rise. The engine speed will increase to 'idling' (34 per cent rev/min) and the jet-pipe temperature reach 750 deg C (it is permissible, under adverse conditions, for the temperature to temporarily exceed the limit of 750 deg C but it must not exceed 800 deg C).

(3) Check that:-

(a) The fire warning indicator lights are out.

(b) The HYD (standard warning indicator unit) and HYD 2 (auxiliary warning indicator panel) lights are out.

(4) Gradually opening the throttle, check that:-

(a) The FUEL 2 warning light has gone out (this should occur at 38 per cent rev/min).

(b) The OIL 2 warning light has gone out (this should occur by the time 45 per cent rev/min is reached).

(c) The GEN lights (standard and auxiliary warning indicators) have gone out.

(d) The hydraulic services pressure gauge reads 3000 ± 250 lb/in².

(e) The hydraulic brakes accumulator pressure gauge reads 3000 ± 100 lb/in².

(f) The No. 2 jet-pipe nozzle position indicator reads 'cruise' (this coincides with the needle being within the yellow arc).

(5) Further increase the speed and check that the TURB warning light and the A.C. warning light (both on the auxiliary warnings panel) have gone out (at a speed not in excess of 65 per cent rev/min).

(6) Move the control handle back to the FAST IDLING stop and check that the TURB and A.C. warning lights remain out.

(7) Move the control handle back to IDLING.

(8) Repeat (2), (3) and (4) for No.1 engine, checking that:-

(a) All the standard warning indicator lights are out.

(b) All the auxiliary warning indicator lights, with the exception of the canopy light, are out.

Note...

(1) *Engine running with No.2 hatch removed can be done only with an external electrical supply.*

(2) *A continuous watch on the voltmeter must be kept to ensure that 28 volts is being maintained at the aircraft main busbar.*

(3) *If any of the above conditions are not obtained, investigation must follow engine shut-down.*

FAILURE TO START

Engine

4. If the engine fails to rotate, repeat the starting procedure after waiting one minute. A third attempt may be made after a further one minute wait but if this too is unsuccessful, the starter system is suspect. Should the engine rotate but fail to light up, move the associated engine control to the H.P. COCKS OFF position as quickly as possible; if this is done without delay there may be no need to adopt the procedure for clearing unburnt fuel from the engine although, in any event, the jet pipe should be inspected for indication of its presence. If the presence of unburnt fuel is suspected, motor the engine for a period of twenty seconds to get rid of it, using the same procedure as that for starting but with the ignition switches OFF, fuel pump switches OFF and engine controls closed to H.P. COCKS OFF.

5. The ignition units for each engine can both be checked for functioning by removing, in turn, their circuit fuses to ensure that only one unit can operate at a time, and then pressing the appropriate RELIGHT button. The fuses to be removed (*refer to the Maintenance Manual, Sect.6, Chap.7*) are those feeding circuits JA1 and JA3 (No.1 engine) and JA2 and JA4 (No.2 engine). Indication that an ignition unit is functioning is provided by a loud cracking sound as the high-energy spark discharges across the igniter plug gap. Upon the conclusion of the checks, any fuses which have been removed must be refitted at their correct locations. Before commencing any work on the ignition system equipment observe the LETHAL WARNING regarding energy which may be stored in the high-energy ignition units.

Note...

Three consecutive normal engine starts may be made from cold at inter-

vals as close as possible to one minute, but a cooling period of 45 minutes, or an engine run of not less than 15 minutes must precede a fourth, or any subsequent, start.

Starter system

6. Failure of an engine to start due to a fault in the starter system may be classified as one of four types of failure, as follows:-

- (1) Starter circuit fuse blows when an attempt to start is made.
- (2) System fails to start when the cockpit push-button is pressed.
- (3) 'A' failure, i.e. when combustion of starter fuel fails to take place and the system shuts down after 0.5 to 3.2 seconds of operation.
- (4) 'B' failure, i.e. when combustion is initiated but is not sustained for the normal 5 to 7 seconds; this condition is usually recognisable by a momentary heavy discharge of gases from the exhaust pipe, followed by shutting down of the starter system.

In the event of a starter system failure there will be no engine rotation indication on the engine speed indicator. If starter combustion does not occur (an 'A' failure) or occurs for less than one second (a 'B' failure) a further attempt to start may be made after an interval of one minute (during which the engine-control handles must be at H.P. COCKS OFF). Up to six attempts to start may be made, at one-minute intervals, where 'A' and 'B' failures occur each time, as no heat factor is involved. A sixth failure indicates a need to investigate the cause of failure.

RUNNING THE ENGINES

Note...

Take-off rev/min (102.5 per cent) is the datum from which all engine speeds must be calculated.

Limitations

7. No.2 engine may be run without restriction, provided that No.1 engine is not running.

Running of No.1 engine while No.2 engine is stationary may impose severe stresses upon the compressor blades, especially at high rev/min. If it is required to run No.1 engine, No.2 engine should also be run at a minimum speed of 60 per cent rev/min. Only if it is essential should No.1 engine be run by itself and then its speed must not be allowed to exceed 50 per cent rev/min.

When both engines are running and it is required to speed up one to

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maximum rev/min the other engine must be maintained at a minimum of 50 per cent rev/min to avoid excessive j.p.t. on the slower-running engine.

85 per cent rev/min on both engines simultaneously must not be exceeded because of braking limitations and only if it is essential should both engines be run together at this speed.

If the ground electrical supply is disconnected and both engines are running, one engine must be maintained at 60 per cent rev/min if the other is idling to ensure an electrical supply for aircraft services.

The appropriate engine hatch and jet-pipe compartment access panels 74 and 76 (port and starboard) and 82 and 86 (starboard) are to be removed if ground running is to be of more than a total of 20 minutes duration or involves more than 5 minutes running of an engine at speeds greater than 60 per cent rev/min.

8. Ground running is to be kept to a minimum; the maximum permissible engine running times are as follows:-

| | |
|--|------------|
| (a) Testing No.1 engine with No.1 hatch removed and No.2 engine running at the required speed | 15 minutes |
|--|------------|

| | |
|--|------------|
| (b) Testing No.2 engine with No.2 hatch open and No.1 engine stationary | 30 minutes |
|--|------------|

(c) Either of the above running times are to be followed by a cooling period of 1 hour with engine stopped.

(d) Running at maximum speed during the foregoing checks is to be kept to a minimum and alternated by running at reduced rev/min.

(e) Continuous running at maximum rev/min for either engine is not to exceed 5 minutes, or for both engines together must not exceed 3 minutes.

(f) Continuous running in reheat on any one engine must not exceed 1 minute.

CHECKS

9. To keep ground running time to a minimum, it is recommended that the following sequence of checks is used.

(1) *Intake guide vane ram.* - Slowly accelerate the engine from idling rev/min, ascertain that the ram is operating within safe limits, then, if satisfactory, exercise the ram several times throughout its operating range. Run the engine at 95 per cent rev/min for approximately three minutes to stabilize engine temperature, then open the throttle to maximum rev/min. Close the throttle slowly and check that the ram leaves

the minus 13 deg position at 98.5 to 99.5 per cent rev/min. Continue to decelerate until approximately 87 per cent rev/min is reached, then check that on acceleration the ram leaves the plus 38 deg position at 88 to 89 per cent rev/min. A variation in ambient temperature will affect ram settings and this must be taken into account when checking and setting the ram. Add 0.125 per cent rev/min for each degree above 15 deg C and deduct 0.125 per cent rev/min for each degree below 15 deg C.

(2) *Bleed valve.*- Check that the bleed valve functions correctly and within the limits over the operating range, by feeling for the airflow from the bleed-valve duct whilst slowly accelerating and decelerating. The bleed valve should close on acceleration and open on deceleration at $88.5 \pm \frac{1\frac{1}{2}}{5}$ per cent rev/min.

(3) *Engine anti-icing.*- Stabilize the engine at 75 per cent rev/min and note the rev/min and j.p.t. Switch anti-icing ON; correct functioning is indicated by a small decrease in rev/min and an increase of approximately 20 deg C in j.p.t. Switch anti-icing OFF and check that engine rev/min and j.p.t. return to approximately the original readings.

(4) *Two-position nozzle control (non-reheat).*- From ground idling open the throttle slowly to governed speed and check that the two-position nozzle moves the propelling nozzle to the closed position at 95 ± 1 per cent rev/min. Retard the throttle slowly and check that the switch moves the nozzle to the open position at 87 ± 1 per cent rev/min.

(5) *Governed rev/min.*- Switch OFF the top temperature control switch, then carefully open the throttle fully to the maximum rev/min position, checking that the governed speed and j.p.t. do not exceed the limits specified in operation limitations. Return the top temperature control switch to AUTO and wire-lock.

(6) *Idling speed.*- Check that the engine stabilizes at normal idling rev/min and that the j.p.t. does not exceed the idling limitation.

(7) *Acceleration time.*- Before checking the acceleration time, check that the top temperature control is at AUTO and that the anti-icing switch is OFF. Stabilize the rev/min at 34 per cent then make a 'slam' acceleration to governed rev/min. The time taken to accelerate the engine from 34 per cent to 99 per cent rev/min should not be less than 8 seconds (7 seconds when the intake debris guard is fitted). Throttle back to 60 per cent rev/min and make a 'slam' acceleration to governed rev/min. The engine should accelerate to 95 per cent within 5 seconds.

Note...

Variations in ambient temperature will affect the acceleration times. During operation in extremely hot climates the acceleration time will

be extended (slower acceleration), and in extremely cold climates will approach its minimum value (faster acceleration).

STOPPING THE ENGINE

10.

(1) Move the engine controls to H.P. COCKS OFF. When the engines have stopped, switch OFF:-

The fuel pump switches

The fuel cock switches

The engine start master switch

The battery master switch

The instrument master switch

(2) Check that the engines run down freely. After they have stopped, check and if necessary replenish, the oil levels.

(3) Fit the air-intake and jet-pipe blanking plates, if they are available, when the engines cool.

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