

**SECTION 2**

**STARTING AND GROUND RUNNING**

**RESTRICTED**

## **SECTION 2**

### **STARTING AND GROUND RUNNING**

## **LIST OF CHAPTERS**

*Note.—A list of contents appears at the beginning of each chapter*

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**2 Starting and checking**

**RESTRICTED**

## Chapter 1

## PREPARING FOR SERVICE

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## General

1. This chapter outlines the operations necessary to prepare a newly installed, or previously stored E.C.U. for service. A full description of each operation will be found in the appropriate sections of this volume or in the Aircraft Air Publication.

2. It is assumed that all installation checks have been completed as instructed in Sect.1, Chap.1, and that the air intake cowling is in position. All other cowlings may be left off to facilitate external checks and adjustments.

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## Preparing for ground running

3. The battery master switch must be at OFF and the cartridges removed from the turbo-starter, as instructed in Chap.2, before commencing work on the engine.

4. Use a ground battery or other suitable external source of electrical supply when making checks.

5. Bleed the fuel system of air and inhibiting oil, as instructed in Vol.6, Part 1, Sect.2, Chap.6. If more than one L.P. pump is fitted to the aircraft fuel system, each pump should be operated in turn during bleeding to clear air from the fuel delivery pipes.

6. Check that the accessory gearbox contains oil to the correct level on the dipstick.

7. Ensure that transportation blanks and sealing tapes are removed from all outlets to atmosphere.

8. Switch on the fuel pump isolating valve and listen for the click of the solenoid then, turn the switch to NORMAL.

9. Check that each igniter unit is operating satisfactory, as instructed in Sect.3, Chap.1.

10. Check the operation of the engine anti-icing equipment, by making the electrical and functional checks, as instructed in Sect.3, Chap.1.

11. Remove the dust covers from the air intake and from the rear end of the jet pipe, then carefully check that no loose objects have been left in the vicinity of the engine.

#### Ground test

12. Ground test the engine, as instructed in Sect.2, Chap.2. Check the fuel and oil system for leaks, and after the engine has been switched off and is running down, that no rubbing sounds are heard from the rotating assembly and the fuel drains are functioning satisfactory.

#### Cowlings

13. After ground test, clean the cowlings internally then, fit them as instructed in the relevant Aircraft Air Publication. Ensure that all the couplings to atmospheric vents are correctly aligned.

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**Chapter 2**  
**STARTING AND CHECKING**  
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PRECAUTIONS

1. The life of a gas turbine engine is adversely affected by high jet temperatures and rapid changes in temperature; unnecessary starts, sudden accelerations and prolonged running at maximum conditions should, therefore, be avoided.
2. The jet pipe temperature must not exceed the maximum figure quoted in Operating Limitations. During accelerations the gauge readings will lag behind the actual temperature in the jet pipe; sudden rev/min changes accentuate this lag and careless throttle handling may result in the maximum permissible temperature being exceeded without indication on the gauge.
3. If during acceleration the engines shows signs of compressor surge (a rumbling noise, possibly accompanied by high j.p.t.), close the throttle immediately; if the engine then runs normally, open the throttle slowly to the desired rev/min.
4. Ensure the aircraft is headed into wind with chocks in position and that the ground in the vicinity is free from loose stones and debris. All personnel must be kept clear of the air intakes and the jet pipes and must observe the precautions listed in A.M.O. A.249/57 and A.P.(N)140. If the oil temperature is below minus 40°C., the engine must be heated by some external method before attempting to start.
5. Take particular care that the starter cartridges used are of the correct type and fully serviceable (para.46).

Starting the engine

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6. If the engine has not been run for some time, fuel vapour may have accumulated in the combustion system. Ventilate the engine by removing the air intake and propelling nozzle cones, a sufficient time for the vapour to disperse, before starting or making a functional check of the ignition system.
7. Start the engine in accordance with the instructions given in the appropriate aircraft Ground Handling Notes (Canberra - A.P.9326 series; Hunter - A.P.4347 series).
8. In icing conditions, ground running must be restricted, as shown in the following table and in para.9.

Ambient temperature	Visibility	Action
<u>Mk.109</u>	Less than +2°C. and less than 500 metres	Ground run in emergency only with anti-icing ON. Use throttle with care. Keep constant watch for formation of icing on aircraft air intake; if icing occurs, stop the engine immediately
	Less than +5°C. and less than 1000 metres	Ground run with anti-icing ON. Use throttle with care.
<u>Mk.122</u>	Less than +5°C. and less than 1000 metres	Ground run with anti-icing ON. Use throttle with care. The distance measuring equipment aerials in the aircraft intakes are particularly prone to ice formation. If ice is observed on the aerials, stop the engine.

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Note...

When anti-icing is ON, acceleration checks are not permitted, and i.g.v. ram and air bleed valve settings will not be valid.

9. If visibility is greater than 1000 metres, icing will not occur at low temperatures and no restrictions are necessary.

10. Deleted

11. When engine rev/min stabilize at ground idling (Operating Limitations), check that oil pressure is indicated and that jet pipe temperature (j.p.t.) is within the limits given in Operating Limitations. Make the cockpit checks listed in the appropriate Ground Handling Notes.

Failure to rotate

12. If the engine fails to rotate, check the starter switches and, if these are correctly selected repeat the starting sequence. If the engine fails to rotate after a second attempt, check and rectify as described in Part 3, Sect.1.

Failure to light up

13. If the engine rotates but fails to light up, turn the h.p. cock off without delay. Allow the engine to come to rest and wait five minutes for the fuel to drain. Normally, if the h.p. cock is closed soon enough, excess fuel will not accumulate in the engine, but if it is suspected that fuel has accumulated perform a motoring cycle, by following the starting sequence but with the h.p. cock at OFF and the ignition made inoperative by disconnecting the l.t. sockets from the high-energy ignition units.

14. After the engine has stopped, check that the igniter units are functioning correctly as described in Part 3, Sect.1, and rectify if necessary.

Ground checks

15. The ground checks described are necessary, in full, only after a post-installation ground run. The appropriate individual check is sufficient to investigate a suspected defect, or to prove a particular rectification.

16. To keep ground running to a minimum, it is recommended that the checks be made in the following order:

- (1) Fuel pump isolation (Mk.121 and 122)
- (2) Maximum continuous rev/min
- (3) Engine anti-icing
- (4) Intake guide vane ram
- (5) Bleed valve
- (6) Governed rev/min
- (7) Ground idling rev/min
- (8) Acceleration
- (9) Fuel and air dip (Mk.121 and 122)
- (10) Throttle synchronizing (Mk.109)
- (11) Top temperature control (Mk.121 and 122)

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17. If the ground running checks indicate that adjusting and/or rectifying is necessary, refer to the appropriate instructions in Vol.6, Part 1, Sect.2.

Fuel pump isolation

## CAUTION...

CARE MUST BE TAKEN WHEN OPENING THE THROTTLE TO AVOID OVER-TEMPERATURING AND ENGINE SURGE.

18. To check the fuel pump isolating system, accelerate the engine to 6000 rev/min then, set the appropriate switch to ISOLATE. Correct operation will be indicated by an increase of approximately 500 rev/min. Reset the isolating switch to NORMAL. The engine may overheat if fuel pump isolating is checked below 6000 rev/min.

Maximum continuous rev/min

19. Accelerate the engine to maximum continuous rev/min, checking that the jet pipe temperature does not exceed the limit (Operating Limitations). Check that the engine oil pressure is not less than 15 lbf/in<sup>2</sup>.

Engine anti-icing

20. While the engine is stabilized at maximum continuous rev/min, switch engine anti-icing to OPEN, then check that the indicator shows anti-icing in operation. After a necessary pause to allow the hot-air valve to open fully, check the j.p.t. has increased by approximately 30°C. (A slight change in rev/min is probable).

21. Return the switch to SHUT and check the j.p.t. and rev/min return to approximately their original values. Residual heat may keep the j.p.t. slightly above its original figure.

Inlet guide vane ram

## CAUTION...

THE INLET GUIDE VANE RAM IS NOT TEMPERATURE COMPENSATED. DO NOT CORRECT OBSERVED REV/MIN FOR AMBIENT TEMPERATURE VARIATION.

22. Ensure the anti-icing valve is shut before beginning this check.

23. Smoothly accelerate from idling rev/min to ensure the i.g.v. ram and air bleed valves are functioning.

24. Accelerate the engine to maximum continuous rev/min (Operating Limitations) and allow the engine to soak for three minutes to stabilize engine temperature. Decelerate slowly and check the rev/min at which the ram leaves the fully retracted (-2° Mk.109 or -3° Mk.122 vane incidence) position. Continue to decelerate to approximately 150 rev/min below that at which the ram is fully extended, then accelerate slowly and check the rev/min at which the ram leaves the fully extended (40° vane incidence) position. Mk.109 i.g.v. rams should operate within the limits specified in Table 1, the restricted limits being observed prior to and during operation in high ambient, sea level temperatures of 25°C. and above. Mk.122 i.g.v. rams should operate within the limits specified in table 1A.

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Table 1

Inlet guide vane operating limits - Mk.109

i.g.v. ram movement	Ambient temperatures at sea level	
	25° C and above	below 25° C
Ram leaves minimum incidence position (-2°) on deceleration	7500 -25	7450 ±50
Ram leaves maximum incidence position (+40°) on acceleration	6450 ±150	6400 ±100

I.G.V. ram (Mk.109) extension of limits

26. Certain inlet guide vane rams on Mk.109 engines in service will have been set by the manufacturer to an operating range from 900 to 1200 rev/min within the limits  $6200 \pm 100$  and  $7250 \pm 50$  rev/min. As an increase in rev/min at which the ram operates will extend its range of operation, it may not be possible to set those mentioned above within the limits (Table 1). A lower limit of 6250 rev/min is therefore acceptable for Mk.109 engines that cannot be brought within the range, provided the engine gives no indication of surge during an acceleration check (para.35).

Table 1A

Inlet guide vane ram operating limits - Mk.122

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i.g.v. ram movement	rev/min
Ram leaves minimum incidence position (-3°) on deceleration	$7550 \pm 100$
Ram leaves maximum incidence position (+40°) on acceleration	$6400 \pm 100$

Setting allowance for change in fuel (not applicable to Mk.109 ram prior to, or during, operation in ambient sea level temperatures of 25°C. and above)

27. The i.g.v. ram governor pump (which originates the signal for ram operation) is sensitive to changes in fuels used when their viscosity and specific gravity (S.G.) differ, because Mod.687 does not fully compensate for such changes. If, therefore, the i.g.v. ram setting is checked while using a fuel having a S.G. other than that in use during its prior setting, the ram will operate at higher rev/min if the fuel in use has a lower S.G. than that previously used, and vice-versa.

28. It would reduce, or obviate, the need for adjusting the ram when the fuel is changed if the rev/min limits were wide enough apart to include the effect of the change in S.G., but experience shows that, under adverse conditions, compressor surge can occur and relatively narrow limits have consequently to be imposed. To minimise the need for subsequent ram adjusting on change of fuel, set the ram near the upper limit when using Avtag, and the lower limit when using Avtur.

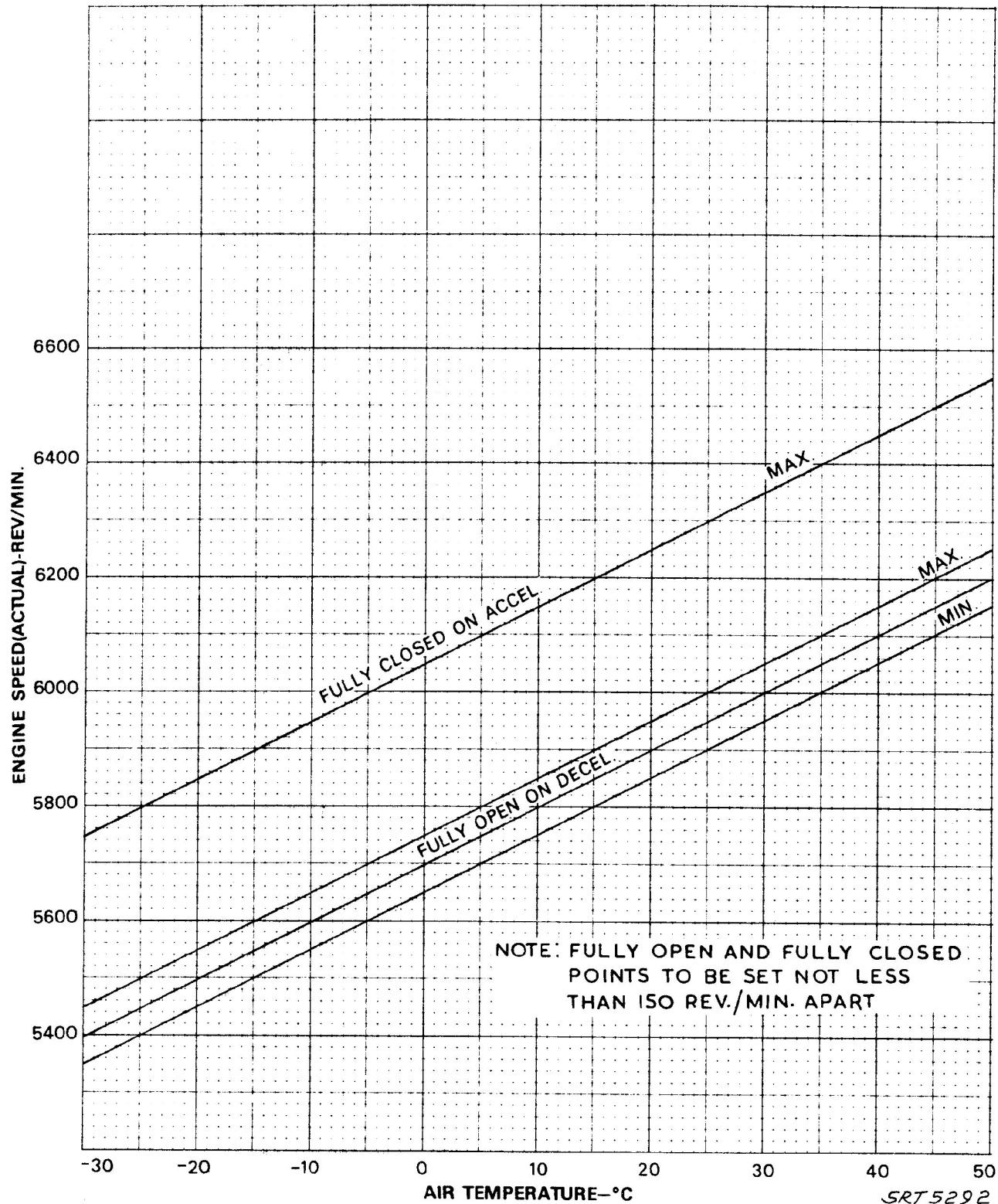
#### Air bleed valves

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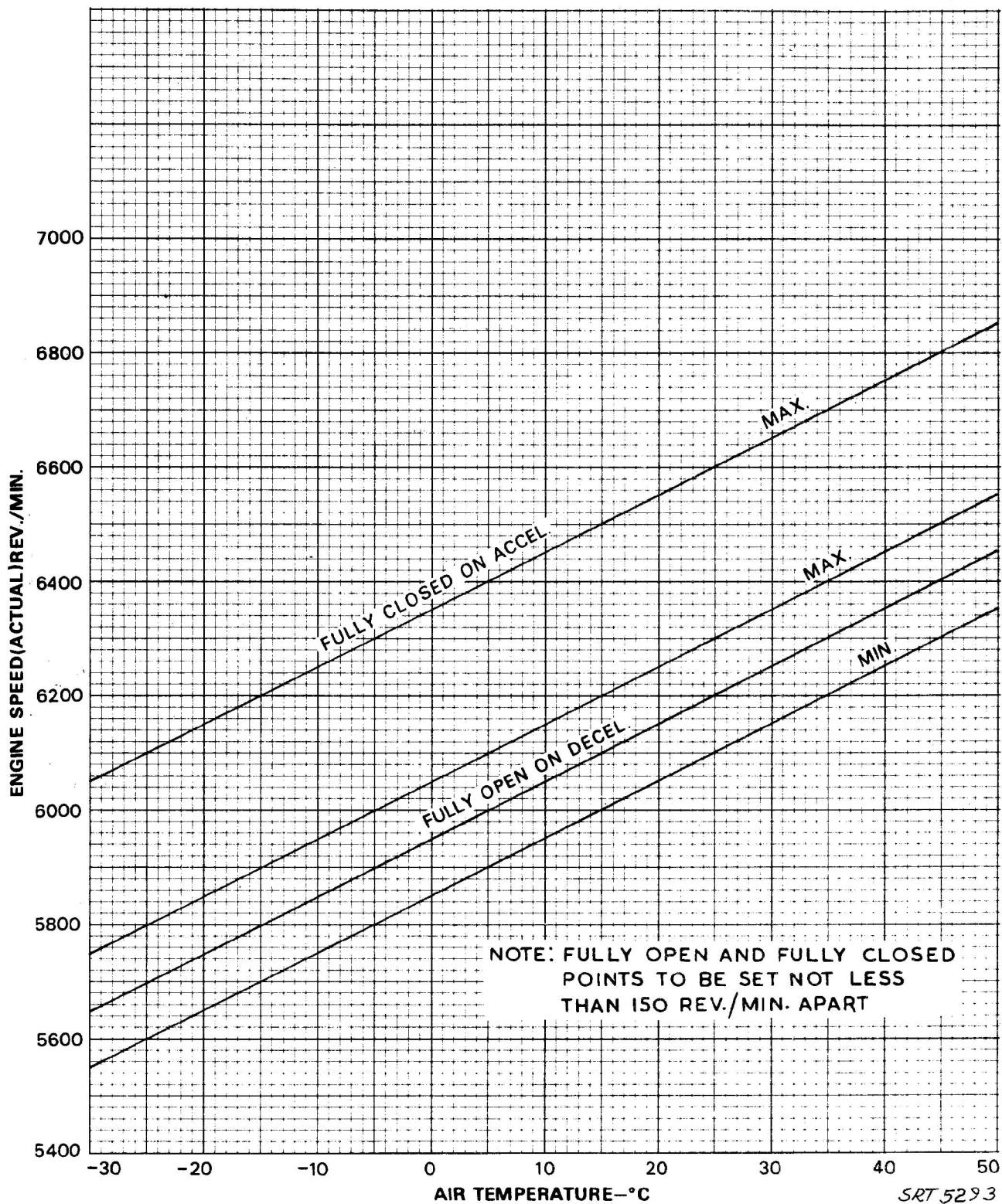
30. Mk.109, 121 and 122 Air bleed valve operating checks.

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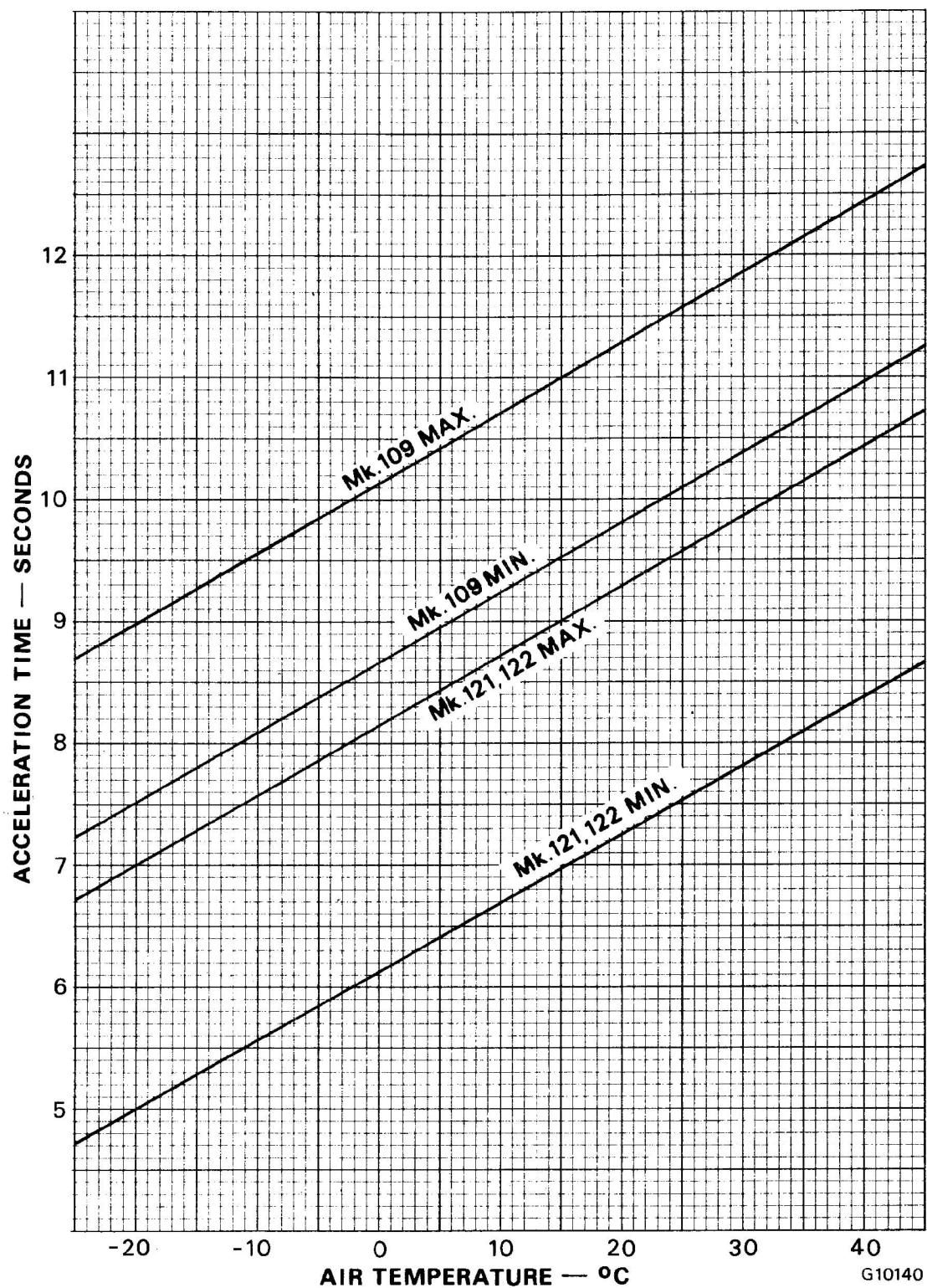
- (1) Note the ambient air temperature. Ensure anti-icing is switched 'OFF' then smoothly accelerate the engine from idling rev/min to ensure the air bleed valves are functioning.
- (2) Accelerate the engine, approximately to maximum continuous rev/min (Operating instructions) and allow the engine to soak for three minutes to stabilize engine temperature.
- (3) Using a throttle rate of approximately 25 rev/min per second decelerate until the air bleed valves 'OPEN'. Record the observed rev/min for reference ..
- (4) Reduce engine speed to 200 rev/min below the 'FULLY OPEN' position then, smoothly accelerate (25 rev/min per second) until the air bleed valves 'FULLY CLOSE'. Record the rev/min for reference.
- (5) Having previously noted the ambient air temperature, check that the bleed valves operate within the limits shown in Fig.1 (Mk.109) and Fig.2 (Mk.121 and 122).



Air bleed valve setting curve - Mk.109  
Fig.1



Air bleed valve setting curve - Mk.121 and 122  
Fig.2



Acceleration setting curves - Mk.109,121 and 122  
Fig.3

## Governed rev/min

31. Open the throttle fully and check that the governed rev/min and jet pipe temperature are within the limits (Operating Limitations).

32. Before comparing the observed rev/min with the specified limits, the former must be corrected for variation in ambient temperature from 15°C. Between 15°C and -10°C, add 1 rev/min for each degree the temperature is below 15°C. Add a further 3 rev/min for each degree the temperature is below -10°C.

33. At ambient temperatures below -13°C engine speed may be limited, by the b.p.c., before the governor can operate. Before checking governed rev/min at ambient temperatures below -13°C, therefore, disconnect the servo pressure pipe (h.p. pump to the b.p.c.) at its connection to the pump; blank the pump and the pipe. Remove the blanks and restore the servo pressure pipe connection when the check is completed.

## Ground idling rev/min

34. Check that the engine stabilizes at ground idling rev/min (Operating Limitations) and that j.p.t. does not exceed the ground idling maximum, then open the throttle to 3500 rev/min and check that the oil pressure is not less than 10 lbf/in<sup>2</sup>.

## Acceleration

35. Check that engine anti-icing is switched off.

CAUTION. . .

EXERCISE CARE, DURING ACCELERATION CHECKS WHEN THE A.C.U. SETTING IS SUSPECT OR HAS BEEN ADJUSTED. OPEN THE THROTTLE SEVERAL TIMES, SLOWLY AT FIRST AND INCREASING THE RATE OF OPENING UNTIL A FAST ACCELERATION IS ACHIEVED.

36. Stabilize the engine at ground idling rev/min and then open the throttle fully and quickly; the time taken for the engine to reach governed speed should be within the limits shown in Fig.3. Avon Mk.109 engines in Canberra installations should have their acceleration times adjusted within one second of each other.

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37. Decelerate to 4,500 rev/min and note the time taken for the engine to accelerate to governed rev/min; the time taken should not exceed 5 seconds.

Fuel and air dip (Mk.121 and 122)

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The fuel and air dip units are rendered inoperative, below a predetermined altitude, by a barometric switch. Before ground testing, isolate the barometric control at the test switch on frame 16 in the radio bay.

38. Run the engine at 7800 rev/min and then select TEST on the fuel dip switch, for a period of 3 seconds. Check, during the period, that air flows from the air dip bleed valve ducts and that there is a drop of 300 to 450 in engine rev/min. When, at the end of the period the switch is returned to NORMAL, check that the engine rev/min increase to 7800.

Throttle synchronizing (Mk.109)

39. Run each engine, in turn, and mark off the throttle positions, on the quadrant, at 5000, 6000, 7400 and 7600 rev/min. Check that throttle stagger is not in excess of 1/8 in.

Top temperature control (Mk.121 and 122)

CAUTION. . .

ON COMPLETING THE CHECK, REMOVE THE TEST RESISTANCE FROM THE AMPLIFIER, REFIT THE ORIGINAL RESISTANCE, AND RETURN THE TOP TEMPERATURE CONTROLLER TO 'ON'. REPLACE THE TELL-TALE WIRE AS SPECIFIED IN THE AIRCRAFT SAFETY AND SERVICING SCHEDULE AND OPEN THE UNDERCARRIAGE MICROSWITCH.

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40. As the j.p.t. does not normally attain the top temperature control limit setting during ground running, the system must be tested by removing the temperature resistance from the amplifier and fitting a test resistance which will operate at approximately 100°C lower than the maximum limitation (Operating Limitations). Before starting the engine, close the undercarriage microswitch so that the top temperature control can operate.

41. Run the engine and, with the top temperature control switched to 'ON' accelerate and check that the jet pipe temperature is controlled at the value marked on the test resistance. Close the throttle, switch the top temperature control 'OFF' then accelerate and check that the normal jet pipe temperature and governed rev/min. are attained.

## STOPPING THE ENGINE

42. Stop the engine as described in the Ground Handling Notes in the appropriate Aircraft Publication series (para.7).

43. Check that the engine runs down freely, without unusual noise and in not less than 35 seconds. After the engine has stopped, check the oil level (Part 2, Sect.3, Chap.1).

## LOADING AND UNLOADING THE STARTER

## Checking the cartridge

44. Before loading the starter, check that each cartridge is of the correct type (Leading Particulars). Reject any cartridge that has a damaged case, flange, lip of sealing cap. Invert the cartridge and shake it gently; if loose black granules drop into the sealing cap, reject the cartridge.

## Loading the starter

45. Check that the starter master switch is at OFF, then remove the starter fairing nose cap, or access panel. Access to Mk.109 starters is gained by unlocking and unscrewing the nose cap, using the two locking handles.

46. Depress the large, central plunger in each breech cap star wheel and unscrew the cap until the ratchet disengages. Release the plunger and then fully unscrew the cap.

47. Assemble a new cartridge into each breech cap, ensuring that each cartridge rim is gripped by the spring-loaded claws in the cap. Ensure the breech is clear of debris then, insert each assembly into the breech barrel and screw the cap into position. Engagement of the ratchet will be indicated by clicking as the cap is screwed in. Screw the caps in finger-tight only, they may otherwise jam.

48. Refit the starter fairing nose-cap or aircraft panel.

## Unloading the starter

49. Withdraw the cap and cartridge assemblies (para.47 and 48), ensuring that the breeches are clear of any debris. Remove the cartridge from the breech cap by depressing the two small plungers in the cap, to lift the spring-loaded claws then, withdraw the cartridge.

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