PART 1 : SECTION 2

CHAPTER 5

STARTING AND TESTING PISTON ENGINES

Introduction

1. This chapter is concerned mainly with supercharged engines driving constant-speed propellers, but the principles apply, as appropriate, to all types of engines. Mishandling of the engine and its controls during the starting and testing phase of any flight can cause damage and excessive wear and tear, thus shortening the life of the engine considerably. Although an engine may be capable of delivering high powers, it is in fact a delicate and sensitive piece of precision engineering built to very fine limits ; careless and harsh usage can quickly cause damage. Properly handled and serviced, any engine is a reliable source of power which will operate consistently well within its limitations over a wide range of conditions.

Precautions Before Starting and Testing

2. Before starting the engine, the following points should be observed :—

(*a*) If practicable, the aircraft should be facing into wind to ensure the best possible cooling.

(*b*) No other aircraft or anything else likely to be damaged should be in the path of the slipstream.

(*c*) The aircraft should not be on dusty or stony ground. Slipstreams pick up loose particles, and damage may be caused to the airframe and propeller.

(*d*) Chocks should be in position and/or brakes on.

(*e*) If the aircraft has been standing for some time, the engine should be turned over, preferably by hand, through two revolutions of the propeller in order to break down the oil film which will have formed.

(*f*) With radial or inverted engines, the propeller must be turned by hand through at least two complete revolutions to prevent damage by hydraulic shock caused by oil or fuel draining into the cylinder heads. If this is indicated (by resistance to rotation) the plugs should be removed from the inverted cylinders which should then be allowed to drain.

(*g*) All fuel cocks and engine controls should be set in the positions required by Pilots' Notes for the type.

(*h*) No attempt to use mechanical means for starting must be made when hand cranking is in progress ; otherwise there is risk of damage to the engine and injury to the person operating the handle.

3. The ignition should never be switched on until the engine is ready to be started, but the booster pump between the tank and the engine to be started should be switched on for the period quoted in Pilots' Notes for the type, with the fuel cut-off set to the "off" position, to expel air from the fuel lines. Slow running cut-outs, however, need not be held in the "off" position.

4. A check that the power developed by an engine is within acceptable limits can be made by noting that the r.p.m. at a certain boost are within 50 of those at which the engine should run if in normal serviceable condition. If this test is always carried out at a boost bearing the same relation to the atmospheric pressure at the time of test, the effects on the power developed, of variations in atmospheric pressure, are automatically compensated. This can conveniently be done by checking at a boost equal to the atmospheric pressure, since this is the static reading shown by the gauge when the engine is not running ; this will be zero only when the atmospheric pressure is 1013 millibars. Before starting an engine, therefore, the static reading of the boost gauge should be noted, the engine being later opened up to this static reading for exercising and testing in accordance with the recommendations in para. 38.

Priming

5. The priming pump and fuel lines should be filled by working the plunger rapidly until resistance is felt, and then the pump should be operated by the plunger being pushed home and at once withdrawn steadily, thus giving the pump time to fill before delivering the next stroke. In some aircraft, an electric priming pump, controlled by a push button or tumbler switch, replaces the hand pump. Priming may, if

necessary, be continued while the engine is turning and until it is running smoothly. If the engine fails to start and over-richness is suspected, the engine may be cleared by :—

(*a*) Switching off the ignition.

(*b*) Turning off the fuel.

(*c*) Opening the throttle and having the propeller turned through several revolutions. The electrical starter may be used provided that the precautions, detailed in the following paragraphs dealing with failure to start, are first carried out.

(*d*) The throttle lever should never be "pumped", either before or after an engine has been started ; with many types of carburettor this will cause an unpredictable excess of fuel to be delivered to the induction system if the engine is not running. If the engine is running, an excessively rich or uneven mixture is caused irrespective of the type of carburettor, which may lead to a rich cut or an induction fire and also subjects the engine parts to undesirable fluctuations of loading.

Starting by Propeller Swinging or Hand Cranking

6. Small engines may be started as follows :—

(*a*) Ensure that the wheels are correctly chocked.

(*b*) Prime the cylinders as instructed for the type.

(*c*) If an engine has not been run for some time, or is cold, it may be necessary to have it cranked, or the propeller pulled over by hand, for one or two revolutions with the ignition off and the throttle closed or nearly closed. This ensures that the induction system and as many cylinders as possible contain fuel vapour.

(*d*) Switch on the ignition and have the engine turned over smartly until it starts.

(*e*) If it fails to start after a few turns, over-richness is the probable cause, so switch off the ignition, turn off the fuel, open the throttle and have the engine turned through several revolutions. Then turn on the fuel, close the throttle, and proceed as in sub-para. (*d*).

7. There is always a possibility that, owing to a faulty ignition system, an engine may start when being pulled over by hand with the ignition off. Whenever hand turning a propeller the airman should accordingly take the greatest care, assuming a safe position and treating the propeller as if expecting the engine to fire.

Direct-Cranking Electric Starter

8. The direct-cranking electric starter may be either a separate unit consisting of a motor, a reduction gear and an engaging mechanism, or a motor only with the reduction gear and engaging mechanism incorporated in the engine.

9. **Starting.** To start the engine, the ignition is switched on, the booster coil (if fitted) operated, and the starter push button pressed until the engine fires.

10. **Failure to Start.** To avoid damage to the starter, it should never be operated continuously for more than 30 seconds. If an engine fails to start, a pause of 30 seconds should be made to allow the starter to cool before a further attempt to start is made.

11. If the engine is to be started by hand, a crank handle is needed, but this should not be used in conjunction with the electric motor as injury or damage may result.

Electric Inertia Starter

12. The electric inertia starter consists of a flywheel, a reduction gear, and an engaging mechanism. The flywheel may be energized either by hand or by an electric motor, and the engaging mechanism operated either by hand or electrically by a solenoid.

13. The starter is electrically operated by a single, three-position, manual or pedal switch ; this is moved from a central position, one way to run the flywheel up to speed, and the other way to engage it with the engine.

14. **Starting.** To start the engine, the starter switch is set to the energizing position (usually labelled "START" or "ENERGIZE") for 10 to 15 seconds, or until the humming sound from the flywheel becomes constant ; 30 seconds should, however, not be exceeded. With external battery assistance, 10 seconds should suffice. The ignition, and the booster coil if separately controlled, are then switched on, the starter switch is centralized and, after a momentary pause, set to the position necessary to engage the flywheel with the engine (usually labelled "ENGAGE", "CRANK" or "MESH"). When the engine is running smoothly, the switch is centralized and the booster coil switched off.

15. **Failure to Start.** Should the engine fail to start, the ignition, starter, and booster coil should

be switched off. After the propeller has stopped rotating, the switch should be set to the engaging position to stop the flywheel turning, and returned to the central position. The propeller should be turned forwards through half a revolution to ensure that the starter jaws disengage, and the procedure outlined in para. 14 should then be repeated.

16. To avoid damage to the starter, the switch should never be set to the energizing position after the flywheel has been engaged with the engine and no attempt to re-energize a moving flywheel should be made. The accelerating periods should not be exceeded, and after three attempts to start an engine at least five minutes should elapse to allow the starter to cool before making a further attempt.

Combined Inertia and Direct-Cranking Starter

17. This starter consists of the same assemblies as those constituting the inertia starter described above, except that the installation of a more powerful starter motor allows the engine to be "direct cranked" electrically.

18. The running up of the flywheel and its engagement with the engine is controlled either by separate switches, or by a single, three-position self centring switch usually labelled "START" or "ENERGIZE", and "ENGAGE", "CRANK" or "MESH". A combination of inertia and direct cranking operation is therefore possible.

19. **Starting.** The ignition and the booster coil, if separately controlled, are first switched on. If the starters are fitted with brush-lifting gear for manual starting, "ENGAGE", "CRANK" or "MESH" should be selected momentarily to ensure that the brushes are returned to the commutator. The switch is then set to the energizing position until the sound of the flywheel becomes constant, normally for about 20 seconds, and then it, or the second switch, is set to the engaging position. The switch(es) should be put to "off" when the engine is firing evenly, but should not in any case be kept on for more than 30 seconds. With an external battery plugged in, the necessary energizing period should not exceed 10 seconds.

20. **Failure to Start.** If the engine fails to start, the switch(es) should be put to "off" and two or three minutes allowed to elapse before a restart is attempted, during which time the ignition should be switched off and the propeller turned forward half a revolution by hand in order to disengage the starter from the engine.

21. To avoid damage to the starter, it should never be operated in engagement with the flywheel for more than one minute continuously. If the engine has not started in this time, an investigation should be made to ascertain the cause.

Hand Cranking with Electric Inertia and Inertia Direct-Cranking Starters

22. **Starting.** On these starters it is first necessary to operate the brush-lifting gear to lift the brushes from the commutator. After fitting the cranking handle, the engine is started by turning slowly, gradually increasing the speed up to 70 to 80 r.p.m., which should normally be attained in about one minute. The handle is then removed and the engaging mechanism operated. As soon as the propeller begins to turn, the ignition should be switched on.

23. **Failure to Start.** If the engine fails to start, the flywheel should be allowed to come to rest and the ignition should be switched off before a further attempt to start is made by repeating the operations described in para. 22.

Cartridge Starters

24. Cartridge starters consist of a magazine unit connected to a starter breech. The magazine is loaded with a number of pyrotechnic cartridges, each of which may be indexed into the firing position either manually (by remote mechanical means) or electrically. The cartridges are fired electrically or, in one type, by percussion mechanically. The gas pressure from each cartridge is converted by the starter unit into a rotary impulse sufficient to rotate the engine two or three times at high speed, after which the starter unit becomes automatically disengaged from the engine. There are three main types of cartridge starters, as detailed in paras. 25 to 27.

25. **Manually Indexed, Electrically Fired Cartridge Starters.**

(*a*) *Starting.* With these starters the magazine, holding five cartridges, is rotated to index a fresh cartridge by pulling and then releasing a spring-loaded ring or toggle control. The cartridge in the firing position is then fired electrically by pressing a starter push button, which should be kept pressed until the engine is firing evenly as this push button also operates the booster coil.

(*b*) *Failure to Start.* If a cartridge fires but the engine fails to start, the starter push button should be released and the ignition switched off. When ready for another attempt, the ignition should be switched on again and the indexing control pulled and slowly released to index the next cartridge. The starter push button should then be pressed without delay. After indexing the fresh cartridge, if it is considered unwise or impracticable to start the engine, no personnel should approach the propeller or engine for a period of 30 seconds. This is to guard against the danger arising from the possibility of the engine turning owing to spontaneous ignition of the cartridge caused by heat from the hot grid in the combustion chamber.

26. **Electrically Indexed and Fired Cartridge Starters.**

(*a*) *Starting.* With these starters the magazine, holding five cartridges, is rotated to index a fresh cartridge and then fired electrically by the single action of pressing the starter push button. On pressing the button a short delay occurs during which the magazine mechanism is operating. The push button, which also operates the booster coil, should be kept pressed until the engine is firing evenly.

(*b*) *Failure to Start.* If a cartridge fires but the engine fails to start, the procedure is the same as for mechanically indexed starters. There is, however, no danger of spontaneous ignition.

27. **Manually Indexed and Fired Cartridge Starters.** On these starters, fitted to small aircraft, the indexing control also fires the cartridge. As the handle is pulled a fresh cartridge is indexed and then percussion-fired by mechanical means as the control approaches the fully extended position. On the control being released it springs back, automatically resetting the mechanism ready to index and fire the next cartridge. The magazine holds six cartridges. No starter push button is fitted. There is no possibility of indexing a fresh cartridge prematurely.

28. **Precautions with all Piston Engine Cartridge Starters.**

(*a*) If at any time a cartridge fails to fire when the push button is pressed, or the firing control operated, a period of 30 seconds should elapse before a fresh cartridge is indexed or indexed and fired. During this period of a possible "hang fire", no personnel should approach the engine or propeller. If a fresh cartridge is indexed too soon, whether fired immediately or not, there is a risk of the previous defective cartridge exploding spontaneously in the magazine owing to heat transmitted to it while it was in the firing position. If more than one cartridge in succession fails to fire, a defect in the firing circuit or mechanism is the most probable cause. As a precaution, a period of one minute should be allowed to elapse before the starter is approached by the ground crew for examination or adjustment.

(*b*) Spent cartridges should be removed as soon as possible ; if left for a long period they may corrode and jam in the magazine.

Starting Ignition

29. Booster coils provide starting ignition while the engine is turning over slowly and the voltage generated by the magneto is insufficient to provide the necessary spark. They are controlled by separate push buttons or in some cases by the starter push button. A booster-coil master switch is sometimes fitted.

30. The impulse starter is another means for obtaining starting ignition. It operates by flicking over the magneto rotor by means of a coiled spring ; this ensures that sufficient speed is imparted to the rotor to give the necessary voltage.

Starting on Internal Batteries

31. Engines fitted with electric starters should not, in general, be started on the internal batteries if a suitable external battery is available. Most aircraft batteries have a 40 ampere-hour capacity and for weight considerations their plates are very thin ; prolonged use of the starter will cause the battery to be rapidly discharged and may eventually lead to buckling of the plates.

32. If it is desired to start on the internal batteries, the following points should be borne in mind :—

(*a*) On multi-engine aircraft, an engine driving a generator should be started first and run at r.p.m. sufficient for the gener tor to cut in. The batteries will then have the support of the generator when starting the other engine.

(*b*) Engines should then, if possible, be run above the minimum r.p.m. at which the generators cut in.

(*c*) The use of the electrical services before take-off should be kept to a minimum to conserve the limited power of the aircraft battery.

General Instructions

33. The use of fuel cut-offs, slow running cut-outs, and booster pumps, is dealt with in Chapter 7, "Engine Handling", while their application is given in the relevant Pilots' Notes.

34. In very cold weather, engines which have been stopped long enough for the oil temperature to fall below 0° C. may be difficult to start because :—

(*a*) The oil thickens and prevents adequate cranking speed.

(*b*) The fuel does not vaporize so readily and provide a combustible mixture.

35. To overcome the condition in para. 34 (*a*) oil dilution may be used to make the engine easier to turn, and to ensure an immediate flow of oil to all moving parts, whilst for the condition in para. 34 (*b*) considerably more priming is required than under temperate conditions. Cold starts can be obtained using 100 octane fuel for priming down to −25° C., and high volatility fuel down to −35° C. This latter fuel is supplied to the priming pump from an outside source by means of a selector cock in the pump supply line.

36. The oil pressure should be watched for the first few seconds, after which time, if it has not built up to normal or higher, the engine should be shut down, otherwise damage will occur.

Warming Up

37. The throttle should be opened gradually until the engine is running at about 1,000 to 1,200 r.p.m., or at the speed recommended in Pilots' Notes for the type. The engine should be warmed up at this speed until the prescribed temperatures and pressures have been reached. Gills on radial engines should not be opened until the cylinder head temperatures reach + 100° C., otherwise congealed grease on chains or sprockets may overload and burn out the gill motors. Hot air may be used in cold weather. During warming up, the operation of the hydraulic pump should be tested by operating the flaps and/or bomb doors.

Exercising and Testing

38. The engine can now be exercised and tested as required in Pilots' Notes for the type. The following tests are applicable, where appropriate, to all piston engines. Any differences from this procedure will be given in Pilots' Notes for the type.

39. The following checks will disclose if the engine is running correctly, at the same time ensuring that ground running at high-power settings, damaging to any engine, is kept down to the minimum.

40. As a general rule, ground testing should not be carried out with the carburettor air intake control in the hot position, unless heavy throttle icing is being experienced. If the hot position is used, a slight drop in boost is to be expected. If an intake filter is fitted, this should be in the filter position.

41. During the run-up period, the charging rate of the generator should be checked together with the r.p.m. at which it cuts in. The vacuum pump suction and change-over cock, if fitted, should be checked. Temperatures and pressures should be watched the whole time during the run up to ensure that the instruments are working and that the limitations are not being exceeded.

42. After opening the cowling gills or radiator shutters, ensure that the r.p.m. control lever is set to the take-off r.p.m. position, that the mixture control, if fitted, is in the auto rich or rich position, and that the supercharger is in low gear ; then carry out the following drill :—

(*a*) At warming up r.p.m., test each magneto as a precautionary check against a dead cut.

(*b*) Open up to the static boost reading (zero lbs./sq. in. or 29·92 ins. Hg in standard atmosphere conditions).

(*c*) Exercise and check the operation of the C.S.U. by moving the r.p.m. control lever smoothly over its full governing range. This should be done at least twice to ensure the circulation of warm oil throughout the system.

(*d*) At the same boost, check the operation of the supercharger gear change, if fitted, by engaging high gear. Boost should rise slightly and r.p.m. should drop if high gear has engaged correctly. On certain engines, the supercharger gear change is effected entirely by oil pressure ; high gear should therefore be engaged for 30 seconds to ensure that the clutch plates are cleared of oil sludge. On some installations a red warning light should come on as high gear is engaged. If the supercharger

control is of the automatic type, the engagement of high gear can be checked by selecting "AUTO" and pressing a test push button.

(*e*) At the same boost, return the r.p.m. control lever to the take-off r.p.m. position and note the r.p.m. This reading should be within 50 of the r.p.m. normally obtained and of the figure quoted in the Form 700, in the case of engines for which the reference r.p.m. are established at a stated boost. Correct static r.p.m. for zero boost setting indicates that all cylinders are operating.

(*f*) Test each magneto in turn. If there is marked vibration, the engine should be stopped. If the drop in r.p.m. exceeds the figure specified in Pilots' Notes, but there is no undue rough running, a high-power check may be carried out. A high-power check may also be carried out after repair or servicing other than daily servicing, when the r.p.m. drop exceeds the permitted figure, or at the discretion of the pilot. Before carrying out this check on high-powered single-engine aircraft with tail-wheel undercarriages the tail should be lashed down. If the checks at the static boost reading are satisfactory, no useful purpose will be served by a full-power check.

43. When a full-power check is required, it should follow immediately after the checks at the static boost reading. First ensure that the r.p.m. control lever is set to the take-off r.p.m. position and then :—

(*a*) Open the throttle to the take-off setting and check the boost and r.p.m.

(*b*) Throttle back until a drop in r.p.m. is observed and test each magneto in turn. Throttling back ensures that the propeller is on the fine pitch stops and not constant speeding and, thereby, tending to mask any r.p.m. drop during the ignition check. If the single ignition r.p.m. drop is excessive and cannot be cleared the engine should be shut down.

(*c*) The time spent on these tests should be kept to a minimum.

44. After completing the checks either at the static boost reading or at full power, move the throttle steadily to the fully closed position and check the minimum idling r.p.m., then open up to between 1,000 and 1,200 r.p.m.

This file was downloaded
from the RTFM Library.

Link: www.scottbouch.com/rtfm

Please see site for usage terms,
and more aircraft documents.