EO 10A-1-2AF

ROYAL CANADIAN AIR FORCE

REASONS FOR REMOVAL OF PISTON ENGINES

(This EO replaces EO 10A-1-2AF dated 12 Jun 64)

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LIST OF RCAF REVISIONS

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REASONS FOR REMOVAL OF PISTON ENGINES

GENERAL

1 Engine life is dependent upon many factors such as quality of manufacture or overhaul, type of operation, the aircraft in which engines are installed and the degree to which preventive maintenance is accomplished, based on service operation and maintenance records. The expected life between overhauls of engines is listed in EO 00-50-7, which is revised periodically to show higher engine life expectancy as improvements in engine design and maintenance procedures are effected.

CONTROL OF ENGINE REMOVAL

2 Except in cases of obvious failure, such as complete internal failure, or when the overhaul time as specified in EO 00-50-7 has been reached, engines will not be removed until a complete investigation has been made. When an engine is removed, the cause of removal with complete information relative to the failure or difficulty and maintenance action taken to correct the condition will be included in the report to be submitted, Ref. EO 00-10-1. Oil filters and sumps are to be inspected on time expired engines for possible metal contamination. In addition for Wright R3350 engines only the aircraft oil system is to be cleaned as per EO 05-1-2AX. Before installation of a replacement engine refer to EO 05-1-2AX.

SUSPECTED INTERNAL ENGINE FAILURE

3 Generally metal particles on the engine oil screens or drained from the oil sumps are an indication of internal engine failure. However, due to the construction of aircraft oil systems, it is possible that metal particles may have collected in sludge in the oil system at the time of a previous engine failure; hence, this shall be taken into account when metal particles are found in the engine oil screens or sumps especially on newly installed engines. Frequently carbon will break loose from the interior of the engine in large pieces which have the outward appearance of metal. This can be distinguished from metal by placing the foreign material on a flat metal object and strikin the material with a hammer. If the materi is carbon, it will disintegrate on impact whereas metal will either remain intact o change shape depending on malleability.

NOTE

Numerous engines are being returned to the contractor reported as metal contaminated and on strip investigation, they have shown no evidence of being contaminated or any signs of being unserviceable.

INSPECTION OF ENGINES NOT HAVING EXTERNAL OIL FILTERS

4 Oil systems of engines not having extern oil filters and suspected of internal failure ar to be inspected as follows:

(a) Remove oil screens and filters, inspe for particles. If failure is not obvious, air craft oil system must be cleaned as per E 05-1-2AX and the engine ground run and checke as outlined in paragraph 6.

INSPECTION OF ENGINES HAVING EXTERNAL SCAVENGE FILTERS

5 Oil systems of engines having extern scavenge filters and suspected of internal fai ure are to be inspected as follows:

(a) If metal is found on newly installe engines that have less than 10 hrs since in stallation and the failure is not obvious the shall be checked as outlined in paragraph 6.

(b) If metal is found in the external sca venge filter and the engine oil inlet pressu strainer on engines that have more than hrs since installation, the engine is to l replaced.

(c) If metal is found only in the extern scavenge filter and the source of metal known, i.e. broken valve spring etc., and de

fect can be rectified within unit resources, the engine is to be repaired and checked as per paragraph 6.

(d) If metal is found only in the external scavenge filter and the source cannot be determined, the engine is to be replaced.

(e) If metal is found only in the engine oil inlet pressure strainer, the source of metal is obviously from a contaminated aircraft oil system between the external scavenge strainer and the engine oil inlet pressure strainer. Under this condition, the aircraft oil system must be cleaned as per EO 05-1-2AX and the engine ground run and checked as outlined in paragraph 6.

PROCEDURE FOLLOWING INSPECTION

6 Remove sump plugs and drain oil into a container. Check sump plugs for metal particles. Strain oil through a clean cloth to check for evidence of foreign material. If heavy metal particles are found, indicating a definite engine failure, the engine shall be removed. If small metal particles similar in nature to filings are found, possibly caused by normal engine wear or residue left in the oil system as a result of improper cleaning after a previous engine failure, the oil system is to be drained while hot and refilled with new oil.

(a) Ground run the engine and check for smoothness of operation and power output. If the operation is satisfactory during the ground run, the engine is to be shut down and the oil system rechecked for contamination as outlined in paragraph 6. If there is no indication of heavy metal particles in the oil system, the engine will be given a one hour flight test. If the engine operates satisfactorily during the flight test, the oil system is to be rechecked for metal contamination as outlined in paragraph 6. If no further indication of metal is found, the engine will continue in service. Further checks for metal contamination of the oil system will be carried out after five and ten hours of operation. If no indication of internal failure is found after the ten hour check, the engine will require no further inspection.

SUDDEN STOPPAGE

7 Sudden stoppage is defined as very rapid stoppage of the engine by one or more blades of the propeller striking an object, resulting in the RPM of the engine being reduced to zero and engine stalls. When sudden stoppage occurs, internal damage such as cracked gear teeth, crankshaft misalignment and damaged bearings may result.

8 When sudden stoppage occurs as defined, the engine will be removed and the following notation will be made in Section 4 of RCAF Form L14-7 "This engine removed for overhaul, due to sudden stoppage, refer to EO 10A-1-2AF". For propeller limitations, refer to applicable propeller EO.

SUDDEN REDUCTION IN SPEED

9 Sudden reduction in speed is defined as rapid reduction in engine RPM due to one or more propeller blades striking an object, minor damage occurring to the propeller blade tips; and after impact the object is cleared, the engine continues to run and recovers RPM or the engine is stopped by the operator to prevent further damage.

10 Engines subjected to sudden reduction in speed.

(a) While operating at 1500 RPM or above, the engine will be removed and the following notation made in Section 4 of RCAF Form L14-7. "This engine removed for overhaul due to sudden reduction in speed, refer to EO 10A-1-2AF".

NOTE

Gypsy Major engines subjected to sudden reduction in speed are to be removed for overhaul regardless of RPM.

(b) While operating below 1500 RPM, the following action will be taken:

(1) A thorough external inspection of the engine crankcase and nose section is to be made to determine damage.

(2) Check propeller shaft run out. For methods and limits refer to applicable engine -2 or -3 EO. If the propeller shaft run out does not exceed the limits a serviceable propeller will be installed. On some engines propeller shaft run-out is not permitted. Where limits are not shown in engine -2 or -3 EOs and the

propeller is only slightly damaged as evidenced by nicks, dents and scratches with no indication of blade bending or misalignment the engine may be retained in service.

(3) Perform all engine oil system checks, ground run and flight test procedures listed in paragraph 6.

SHOCK LOADING ROTARY WING AIRCRAFT

11 Reciprocating engines fitted to rotary wing aircraft are not normally subjected to sudden stoppage or sudden reduction in speed. The rotors or transmission system will usually break if the rotors are in collision with any object and the engine will continue to run until shut down. However shock loading of the engine can occur under any of the following conditions:

(a) Main rotor blades colliding with any object with engine and rotors synchronized in mechanical drive.

(b) Transition from auto rotation to powered flight if engine RPM is suddenly increased to synchronize with rotors and a sudden mechanical engagement is made.

(c) During engagement of rotors when starting, if mechanical engagement occurs before rotors and engine are synchronized.

12 If any of the above conditions occur, the rotors and transmission system must be inspected and engine removal or inspection will be governed by the condition found.

(a) Major damage to main rotors or transmission system to the extent that actual breakage or distortion occurs, the engine will be changed.

(b) Minor damage to main rotors or transmission system or major damage to tail rotor perform all engine oil system checks, ground run and flight test procedures as listed in paragraph 6.

(c) If rotors and transmission check serviceable, the engine needs no more than a visual inspection.

CYLINDER LEAKAGE

13 Air cooled engines will not be removed for cylinder leakage unless cylinder replacement exceeds the maximum as per EO 10A-1-2Q.

UNSAFE OPERATION

14 An engine may be removed when the condition is such that safe operation cannot be maintained and repair by replacement by units or mobile repair party cannot be effected.

OIL CONSUMPTION

15 An engine may be removed for high oil consumption under the following conditions:

(a) Oil consumption is such that consistent spark plug fouling results and this condition cannot be rectified by replacement of cylinders as per EO 10A-1-2Q.

(b) When oil oonsumption is sufficiently high that the intended range of the aircraft is affected.

ENGINE OVERSPEEDING

16 The following action is to be taken when an engine overspeed occurs:

(a) Ensure that all relevant facts of the overspeed are entered in RCAF Form L14-1B including:

(1) The maximum RPM and manifold pressure obtained.

(2) The duration in minutes.

(3) The reason for the overspeed if known.

(b) Ensure an entry is made in RCAF Form L14-7, Section 10 for each instance of overspeed.

(c) Depending on the extent of overspeed either carry out the inspection noted in para. 17 or remove engine from service and return for overhaul, refer to Figure 1 for overspeed limits.

17 The following inspection shall apply to air cooled engines. For inspection of Merlin engines refer to EO 10A-15-2E.

(a) Inspect the engine oil system as listed in paras. 4 and 5.

(b) Remove necessary spark plugs and check for evidence of interference between the piston and the valve, if evidence of this condition is found, the engine will be replaced.

(c) ON WRIGHT R3350 ENGINES ONLY, check power recovery turbines for freedom of rotation and loose or damaged turbine blades.

(d) Carry out a leakage test on cylinders, Ref: EO 10A-1-2Q.

(e) Check valve springs for breakage and valve spring locks for security.

(f) Check valve clearances as per the applicable EO for the engine. Any excessive change in valve clearance indicates damage to valve operating mechanism and must be investigated.

(g) ON WRIGHT R3350 ENGINES ONLY, any change in valve clearance in excess of .070 (cold measure), the cylinder or cylinders affected are to be replaced with a serviceable cylinder kit.

(h) Inspect for cracked or damaged cylinder heads and barrels. In the event a cylinder head is discovered cracked or damaged the cylinder will be replaced and the engine remain in service.

(j) Inspect locking devices on cylinder hold down nuts or cap screws for security. If palnuts, locking plates etc., are loose or missing, the cylinder hold down nuts or cap screws are to be checked for tightness to proper torque limits. If looseness is evident, refer to applicable EOs for further action re possible cylinder replacement, stud or cap screw replacement, or both.

(k) When cylinders are removed as a result of inspections called up in preceding paragraphs ensure that:

(1) Particles of broken pistons or rings etc. do not enter the crankcase.

(2) The connecting rod is checked for misalignment. If misalignment is evident, the engine must be removed for overhaul.

(m) Following overspeeding with engine oil operated propellers, remove governor for overhaul. Check operation of the engine propeller governor drive by rotating the engine. Install serviceable governor and new gasket.

NOTE

1610-00-156-5005 governors Harvard Aircraft shall only be removed when overspeed is to 2700 rpm or higher.

(n) Following overspeeding with electric propellers in forward pitch, check synchronizer contactor, propeller alternator and nacelle relay assemblies. Associated circuitry shall also be checked for serviceability.

(p) Following overspeeding with electric propellers in reverse pitch, check that the reverse limit switch is functioning at the correct blade angle.

(q) Propellers overspeeded to the extent listed in Figure (1) are to be removed and returned for overhaul.

(r) Perform all ground run and flight test procedures in paragraph 6.

ENGINE OVERHEATING

18 These limits are for inadvertent overheating and are issued only for guidance to maintenance activities. They must not be construed as raising the present continuous engine operating limitations as published in applicable EOs.

(a) When an engine has been subjected to overheating beyond the maximum permissible temperature prescribed in the relevant EOs, the engine is to be replaced.

EXCESSIVE MANIFOLD PRESSURE & OVERTORQUING

19 These limits are for inadvertent overboost or overtorquing, and are issued only for guidance to maintenance activities. They must not be construed as raising the present engine operating limitations as published in applicable EOs.

(a) When overboosting or overtorquing occurs and exceeds the MAP, torque or time limits outlined in Figure 2 the engine is to be replaced.

(b) When overboosting or overtorquing occurs and does not exceed the MAP and torque limits outlined in Figure 2 but exceed the time limits the engine will be replaced.

(c) When overboosting or overtorquing occurs but does not exceed the MAP, torque and time limits outlined in Figure 2 an entry is to be made in the L14-1B and L14-7, Section 10 indicating RPM, MAP, torque and duration of overboost (or overtorque). The engine will be inspected as follows:

(1) Inspect the oil system as per paras. 4 and 5.

(2) Inspect for cracked or damaged cylinders.

(3) Remove spark plugs and carry out a leakage test on cylinders as per EO 10A-1-2Q.

(4) Ground run the engine, if found satisfactory return the engine to service.

CYLINDER AND PISTON REPLACEMENT

20 Cylinders and pistons must be replaced, in which a piston has experienced a hole burned through the dome or through its side.

CAUTION

An extensive check of oil filters and strainers shall be carried out.

(a) Cylinders and pistons must be rejected in which the piston aluminum material has been fused to the cylinder barrel ID.

(b) FOR WRIGHT ENGINES ONLY - If a piston is damaged to the extent of necessitating rejection of the piston and the basic cause or resultant damage imposes a shock loading to the connecting rods the engine will be replaced.

HYDRAULIC LOCK

21 If an hydraulic lock occurs and visual examination of the affected cylinder shows any discrepancy such as damaged piston, bent articulating rod or articulating rod bushings extruding, the engine will be replaced.

SPARK PLUG COPPER RUN OUT

22 This difficulty is usually the result of pre-ignition and/or detonation whereby abnormally high combustion chamber temperature causes the copper core of the centre electrode to melt and flow. In most cases, the copper will bridge the electrode gap rendering the spark plug inoperative.

23 Visual inspection of the spark plug will disclose copper loss and concavity of the centre electrode if the spark plug is so designed that the copper core is normally exposed. In spark plugs which incorporate a nickel-steel capped centre electrode, this type of failure is characterized by a minute perforation of the cap and the presence of copper outside of the steel cap.

24 When copper run out is noted, it indicates that the cylinder has been subject to excessive temperature 1083°C (1981°F), and the following action is required:

(a) Determine the reason for the overtemperature condition and correct.

(b) Replace affected cylinders or remove engine for overhaul. Refer to EO 10A-1-2Q, Figure 1-4.

(c) Perform all engine oil system checks, ground run, and flight test procedures listed in paragraph 6.

25 The formation of scale on the end of the centre electrode has been confused at times with copper run out. Carbon-lead scale appears as a bulbous formation attached to the end of the centre electrode, seldom protruding beyond its normal diameter. This deposit may be detached readily with a knife blade.

IMPELLER DAMAGE

26 Numerous engines have been removed unnecessarily for minor damage to impellers observed by maintenance personnel during carburetor changes. Only two factors affect impeller serviceability namely; imbalance and damage to the extent that the impeller may fracture. Minor nicks, dents, bruises or scratches caused by a foreign object being injected by the engine will not affect the impeller balance to the extent requiring engine removal. Obvious cracks or broken vanes are reason for engine removal. Rework of this area is performed at the overhaul contractor, and resultant markings should not be mistaken for damage.

Engine	Propeller Removal at Engine RPM	Engine For Inspection RPM	Engine For Removal RPM
Gypsy Major CIG, 10MK1-3 10MK1-3A	2900	2550 - 2675	Over - 2675
Continental O-470-11	3150	3400 - 3600	Over - 3600
O-470-L	3000	2600 - 2800	Over - 2860
Lycoming VO-540BID	NA	3520 - 3600	Over - 3600
Hercules 734	3350	2850 - 3000	3000 rpm for more than 20 seconds Over - 3000
Wright R1820-84	NA	2885 - 3000	Over - 3000
R1820 -82	3350	2885 - 3000	Over - 3000
R1820-103	NA	2780 - 3000	Over - 3000
R2600	3350	2680 - 2880	Over - 2880
R3350	3450	3050 - 3300	Over - 3300
		NOTE In forward pitch overspeed limits for Wright 3350 engines from 3120 to 3300 RPM is permitted on a one time basis only. If the engine overspeeds in this RPM range a second time, it must be removed for overhaul. In reverse pitch overspeed limits for all Wright engines are as follows: 2600 to 2750 RPM - No inspection required. 2750 to 3000 RPM - Inspection required as per para. 17 2820 to 3000 RPM - Permitted on a one time basis only. If the engine overspeeds in this RPM range a second time it must be removed for overhaul.	
Pratt & Whitney R985	3220	2350 - 2700	Over - 2700

Figure 1 (Sheet 1 of 2) (Issue 2) Engine and Propeller Overspeed RPM

Engine	Propeller Removal at Engine RPM	Engine For Inspection RPM	Engine For Removal RPM
R1340-AN1, S3H1, S1H2, S3H1G and S1H1G	3150	2500 - 2700	Over - 2700
R1830	3780	2800 - 3050	Over - 3050
R2000	3240	2800 - 3050	Over - 3050
R2800	3350	2900 - 3100 for less than 5 seconds with slight throttle opening.	2900 - 3100 for more than 5 seconds with slight throttle opening.
		2900 - 3100 for less than 30 seconds with large throttle opening.	2900 - 3100 for more than 30 seconds with large throttle opening.
		3100 - 3350 for less than 5 seconds with large throttle opening.	3100 - 3350 for more than 5 seconds with large throttle opening. Over - 3350
Merlin 224	3600	3000 - 3150 (for less than 5 minutes)	3000 - 3150 (exceeding 5 minutes)
622	3600	3150 - 3500 (for less than 20 seconds)	3150 - 3500 (exceeding 20 seconds) Over - 3500

Figure 1 (Sheet 2 of 2) (Issue 2) Engine and Propeller Overspeed RPM

A01 POWER SETTING TIME LIMITATIONS

27 Where a time limit is specified for a particular power setting and that tir limit is exceeded the engine is to be r placed.

Engine	MAP	Torque PSI	Duration Seconds	Supercharger Position	RPM
Pratt & Whitney R985-AN14B, AN5	5 No Limit	NA	5	NA	2300 & above below 2300
Pratt & Whitney R1340-AN1, S3H1, S3H1G, S1H1G	5 No Limit	NA	5	NA	2250 & above below 2250
Pratt & Whitney R1830-92	5 No Limit	NA	5	NA	2700 & above below 2700
Pratt & Whitney R1830-90C	5 No Limit None permissible	NA	5	Low Low High	2700 & above below 2700 All RPM
Pratt & Whitney R2000 7M2	5 No Limit	NA	5	NA	2700 & above below 2700
Pratt & Whitney R2800-CA15	5 No Limit None permissible		5	Low Low High	2700 & above below 2700 All RPM
Wright R1820-82-84	2 6 No Limit	NA NA	15 15	NA NA	Above 2500 2200 - 2500 Below 2200
Wright R1820-103	3 6 No Limit None permissible	NA NA	15 15	Low Low Low High	Above - 2500 2300 - 2500 Below 2300 All RPM
Wright R2600	2 4 3 None permissible	NA NA NA	15 15 15	Low Low High High	Above 2200 Below 2400 Below 2400 Above 2400
Wright R3350-89A	3 4 7 No Limit 3 None permissible	9 12 21 9	15 15 15 15	Low Low Low Low High High	Above 2600 with water injection Above 2600 (Dry) 2200 - 2600 2200 & below 2200 & below Above 2200

Figure 2 (Sheet 1 of 2) (Issue 1) Overboost and Overtorque Limits for Specified Fuel

Engine	MAP	Torque PSI	Duration Seconds	Supercharger Position	RPM
Wright R3350-32W and Wright R3350-EA1	4	12	15	Low	Above 2600 with water injection
	2	6	15	Low	Above 2600 (Dry)
	5	15	15	Low	2200 - 2600
	No Limit				2200 & below
	3	9	15	High	2200 & below
	None permissible			High	Above 2200
Hercules - 734	None permissible	NA	NA	NA	All RPM

Figure 2 (Sheet 2 of 2) Overboost and Overtorque Limits for Specified Fuel

NOTE

Engine overboost limits or overtorque limits "if equipped with torquemeter" for all Wright engines in reverse pitch are identical to the limits set for forward pitch.