THE ENSTROM HELICOPTER CORPORATION
TWIN COUNTY AIRPORT, P.O. BOX 490, MENOMINEE, MICHIGAN 49858

SERVICE INFORMATION LETTER

Date: October 7, 1977

Subject: Engine Troubleshooting Procedures for Turbo Installations and Idle Adjustments to Correct Engine Roughness and/or Inadvertent Stoppage

Models: F-28C and 280C Helicopters

Effectivity: As Required

1. Introduction

Reports have been received of engine roughness and flight idle problems, including inadvertent stoppage, on Models F-28C and 280C helicopters. Enstrom has made a thorough investigation of these reports and a flight test evaluation of possible malfunctions. For the most part, the reported discrepancies have resulted from minor malfunctions in the engine system which have not been accurately diagnosed and corrected by maintenance personnel in accordance with Maintenance Manual instructions. Flight operations of aircraft having symptoms described hereinafter should be discontinued and proper maintenance performed immediately. The purpose of this letter is to reiterate maintenance procedures and provide a troubleshooting guide for maintenance personnel. In addition, expected engine characteristics are described for pilot's information.

The troubleshooting guidelines cover malfunctions related to:

a. Fuel injector nozzle obstructions.
b. Sump drain check valves.
c. Magneto ignition timing.
d. Fuel injector mixture plate leaking and idle mixture adjustment.
e. Fuel nozzle air check valves.

Normal engine characteristics, as a function of density altitude, are discussed for pilot information, followed by recommended pilot operating procedures in the event of suspected in-flight malfunction.

Items (d) and (e) result in excessive mixture richness which can cause engine stoppage during certain pilot maneuvers (I. e., abrupt power chops). Increasing density altitudes above the base density altitude, where the injector was originally adjusted, aggravates the excessive richness problem.

To make the system more forgiving, injectors should be readjusted at the base altitude of operation and a revised idle mixture adjustment is recommended.

2. Troubleshooting Guide

Step 1 - Fuel Injector Nozzle Obstruction

Operating Characteristics of the Engine:

a. Rough idle (with severe obstruction, a popping exhaust noise).
b. Roughness during high power settings.
c. Engine may quit with power reduction with severe obstruction.
d. Fuel nozzle pressure will indicate slightly higher than normal.
e. Slightly higher MAP setting than normal for conditions.

Fuel nozzles should be flow-checked statically by measured weight or volume. Variance in flow should not exceed 3% of measured weight or volume (reference page 20-15 of Maintenance Manual). This test can be accomplished by removing the nozzles from the engine heads, inserting nozzles into small containers to catch fuel, and utilizing electric boost to flow the system. Observation of the fuel stream from each nozzle should be made to determine any obvious variations. Alternately, an engine analyzer which measures individual cylinder EGT will indicate the obstructed nozzle as a hot cylinder or a cold cylinder, depending on degree of obstruction. Nozzles showing variation should be cleaned and rechecked for proper operation or replaced.

Step 2 - Sump Drain Check Valves Stuck Open

Operating Characteristics of the Engine:

a. Hard starting.
b. Rough idle.
c. Lean mixture at idle. Acceleration may be difficult. Rich mixture at high power settings.
d. MAP will be higher than normal for standard operating conditions.
e. EGT indications will be slightly lower than indicated in F-28C and 280C Flight Manuals on page FM-9-ll.

There are three sump drains--one located at the lowest point in the induction manifold, and two others located laterally in the bottom of the aft engine sump. These valves should be checked for proper operation, i.e., statically open, and each valve should fully close with slight negative or positive pressure (such as caused by blowing through them). If they operate erratically, they should be disassembled and cleaned in solvent. Care should be taken to insure proper disassembly and reassembly of this valve. Disassembly sequence- -remove snap ring, end piece, spring, valve wafer and spring (reassembly in reverse order). Note if thread seal is used on reinstallation of the sump drain check valves, care should be taken to prevent contamination of the valve assembly by thread seal (reference "C" Model Maintenance Manual, page MM -20-15). These sump drains should be inspected no less than every 100 hours.

Step 3 - Magneto Ignition Timing

Operating Characteristics of the Engine:

a. Hard starting.
b. Exhaust popping and kickbacks against the starter.
c. Rough idle.
d. Poor acceleration.
e. Magneto check- -a drop in excess of 125 RPM.
f. EGT measures in excess of 100° variance from right to left magneto with rotor engaged in flat pitch at 2900 RPM.

Excessive temperature variance from right to left magneto indicates timing discrepancies and the ignition system should be checked. Repeated starter kickback during starting or unexplained starter failure on any one specific helicopter may also be caused by ignition system malfunction (reference "C" Model Maintenance Manual, pages MM-18-4, MM-18-5, and MM-20-20, recommending a check at 100-hour intervals or as required). It should be noted that when timing problems occur in the ignition system, a thorough inspection of the entire system should be performed (reference current Bendix D-2000 Series Operational Manual).

Step 4 - Idle Mixture Plates Leaking or Idle Mixture Improperly Set

Operating Characteristics on Excessively Rich Idle Setting:

a. Hard starting, especially in hot ambient conditions.
b. Engine will gallop at idle with noticeable roughness.
c. Excessive smoke emission at idle.
d. Engine may stop after power chops or sudden reduction from high power settings to flight idle, particularly at higher density altitudes.
e. Excessive RPM rise (more than 50 RPM) when leaning slowly with cockpit mixture control.
f. Engine will not stop with mixture control in cutoff position.

Every aircraft should have its idle mixture reset when the density altitude of the base of operation changes more than 2, 000 feet. Proper setting of the idle mixture and RPM for operational field densities can be accomplished by the following procedures:

a. Remove seat back and fire wall access panels.
b. Engine should be started and warmed to operating temperatures (i.e., the green on cylinder head temperature gauge).
c. Idle mixture adjustments should be made with the fuel system boost pump on and the cockpit mixture control in full rich position.

d. The Bendix fuel servo is equipped with a zero backlash idle mixture adjustment linkage. Looking in from the left side of the engine compartment or through the access hole from the left door, the upper jam nut should be loosened and the linkage shaft rotated. Rotating the linkage counterclockwise (shortening the adjustment arm) leans the mixture, and clockwise (lengthening the adjustment arm) richens the idle mixture.

e. The idle RPM screw should be initially adjusted to 1500 RPM.

f. In order to establish a base reference for leaning, the idle mixture should be leaned to a point where the engine runs smoothly but will not accelerate from idle (idle RPM should be kept near 1500).

g. The idle mixture should now be richened very slowly to a point where the engine will just accelerate from idle and show little or no RPM rise (under 25 RPM) with mixture leaning. When the idle is properly set, and with one to two inches of cockpit mixture control shaft showing, the engine will accelerate poorly if at all. It should be further noted that with the idle mixture adjusted properly, as described above, a cold engine may not idle with the fuel boost off. It should, however, idle when hot, boost off or on.

h. Any large RPM variations between fuel boost on and off, or if the engine cannot be shut down with mixture control, indicates internal fuel servo leakage and the unit should be serviced to correct this condition by an authorized Bendix service center or overhaul facility.

I. As a normal operating procedure, on engine shutdown the RPM rise should be observed.

Step 5 - <u>Fuel Nozzle Air Vent System</u>

a. Operating characteristics with ambient static air check valve stuck open:

(1) At high power settings engine EGT may indicate higher.

b. With ambient static air check valve stuck closed or sticky:

(1) Hard starting or will not start.
(2) Excessive smoke emission at idle.
(3) Engine will be excessively rough at idle and low power settings.
(4) Engine may quit on power reductions and/or power chops, particularly at higher density altitudes.

c. Deck pressure air check valve stuck open or sticky:

(1) Engine will be very hard starting or will not start.
(2) Rough at idle and poor acceleration.
(3) Engine may quit at low power settings, power reductions and chops to idle.

d. Deck pressure air check valve stuck closed or sticky:

(1) Engine may quit at power reduction at high density altitude.

3. Normal Engine Operating Characteristics & Pilot Operating Procedures

Recommended operating procedures for turbocharged engines are found in Section FM-3 of the "C" Model Flight Manuals. Other operational information is contained in Section FM-9 including cautionary comment relative to power chop for training on page FM-9-8. Throttle chops should never be performed unless an intended landing site has been selected.

An aircraft with idle mixture and RPM properly set at its base altitude giving 1500 RPM will exhibit decreasing RPM with increasing density altitude. Where the base is sea level, at 12,000 feet the idle RPM will be approximately 1100 RPM. Because the automatic mixture control only affects the high power fuel/air mixture, the idle mixture richens with increasing density altitude. Whereas manual leaning at sea level produces little or no RPM rise, for an engine set up at sea level, manual leaning (or the equivalent leaning caused by "boost off") will produce approximately 400 RPM rise at idle, indicating that the idle mixture is significantly richer.

Extremely rapid power chops from highest power at full rich condition, such as might occur in student training, are the most adverse maneuver the pilot can perform since this causes excessive fuel loading in turbocharged aircraft before the system can adjust to the new power demands. In this type of maneuver, a normal engine will experience transient RPM that decays to below idle setting and then recovers to idle. At any altitude, this decay in the most rapid power chop should not exceed 600 RPM below its idle (i.e., at 12,000 feet, the transient drop may reach 500 RPM and then return to 1100 RPM). Emergency maneuvers, where collective pitch is rapidly reduced together with throttle movement to prevent engine overspeed, are less severe. This maneuver is referred to as a rapid roll-off of power as opposed to a throttle chop. Normal slow power reductions are less severe, but the throttle must be closed to the stop. A cracked throttle essentially acts as if it has richened the idle mixture and, at high altitudes, the engine may "flood out" and stop. Alternately, the power can be reduced holding RPM above 2000 RPM momentarily, giving the turbocharged system time to adjust, and then fully closing the throttle to idle if so desired. Throttle should not be opened until the engine has recovered from its drooped RPM condition, i.e., stabilized at its normal idle RPM.

Operators who suspect possible engine malfunctions while in flight should:

a. Minimize high density operation if practical.
b. Reduce operating manifold pressures.
c. Lean to ECT's between best power and best range (i.e., 1550°to 1650°.
d. Avoid intentional power chops or splitting the needles for altitude changes or landing approaches. If needle split is necessary, hold greater than 2000 RPM or fully close the throttle. Do not leave throttle partially cracked.
e. If an inadvertent power failure occurs after power reduction, stabilize the aircraft in autorotation, turn the boost pump off, and determine the best landing site.

Pull mixture control to full lean and restart the engine (no priming is necessary). With the exception of a magneto ignition problem, the engine should restart and will usually idle, even at the density altitude where it quit, and even with sticky or malfunctioning nozzle vent air valves, leaky injector mixture plates, etc. For this emergency condition, assuming no malfunction of the engine pump, leaving the boost off is favorable and minimizes the possibility of another inadvertent stoppage.

Summary

Several malfunctions and maladjustments of the engine system have caused rough idle and flight idle problems including engine stoppage on power reduction. This service information provides a troubleshooting instruction and a summary guide for proper maintenance. Further, it highlights interim operating procedures and new idle adjustment to minimize the possibility of engine stoppage where condition of malfunction or maladjustment are suspected. Enstrom has developed a system improvement which includes increased reliability of valve systems and reduced susceptibility to engine stoppage in the event of malfunction (i.e.., makes the system more forgiving). These improvements will be the subject of a separate service notice upon completion of FAA certification of the improvements.

SUMMARY OF TROUBLESHOOTING GUIDE

	1. Fuel Injector Nozzle Obstruction	2. Sump Drain Check Valve Stuck Open	3. Magneto Ignition Timing	4. Idle Mixture Plates Leaking or Idle Mixture Improperly Set	5. Fuel Nozzle Air Vent System: a. Ambient Static Air Check Valve Stuck Open	b. Ambient Static Air Check Valve Stuck Closed or Sticky	c. Deck Pressure Air Check Valve Stuck Open or Sticky	d. Deck Pressure Air Check Valve Stuck Closed or Sticky
Hard Starting		X	X	X		X	X	
Rough Idle	X	X	X	X		X	X	
Difficult Acceleration			X				X	
Rough at High Power	X							
May Quit on Power Reduction	X			X		X	X	X
Exhaust Popping; Kickback On Starting			X					
Excessive Smoke at Idle				X		X		
Mixture Will Not Stop Engine Or Excessive RPM Rise				X				
Fuel Nozzle Pressure Higher Than Normal	X							
Higher MP than Normally Req'd	X	X						
EGT Lower than Normal		X						
Magneto Drop in Excess of 125 RPM			X					
EGT Variance Over 100° With Magneto Switching			X					
Lean at Idle; Rich at Power		X						
At High Power EGT Higher Than Normal					X			