Accident Prevention Program

Part I—ENGINE OPERATION FOR PILOTS

by

Teledyne Continental Motors

SAFE ENGINE OPERATION INCLUDES:

Proper Pre-Flight

- Use the correct amount and grade of aviation gasoline. Never use auto gas or jet fuel in aircraft piston engines.
- Use the correct grade and amount of oil in your engine.
  —SAE 50 above 40° Fahrenheit
  —SAE 30 or 10-W-30 below 40° Fahrenheit
- In cold weather make sure that the engine oil is sufficiently warm before starting the engine. Below 20° Fahrenheit, use a heated hangar or preheat.
- Drain the fuel sumps to assure there's no water or foreign matter in the fuel system.
- Make certain cooling air inlets are open and free of foreign objects (bird's nests, etc.).
- Assure that the oil cap and dipstick are properly secured. Check for obvious oil and fuel leaks.

Starting and Warm-Up

Normal and Hot Weather

- Little or no priming is necessary.
- Make run-ups thorough, but as brief as possible. Idle engine at 1000 to 1200 rpm. This will help minimize spark plug fouling.
- Avoid overheating. Keep ground operations to a minimum. Park and run-up into the wind.
- Cowl flaps should be open for all ground operations.

Cold Weather

- Make sure magnetos and master switch are "off", then rotate propeller by hand about six revolutions before attempting to start engine.
- Prime engine as recommended in the Pilot-s Operating Handbook—avoid overpriming.
- Oil pressure should be "in the green" within 60 seconds. If not, shutdown and investigate.

- Operate engine at 1000 rpm until oil pressure is "in the green" and steady. Fluctuating oil pressure means that cavitation is occurring. If it is, shut down the engine and use additional preheat.
- If equipped with a constant speed propeller, cycle it several times to fill the propeller hub with warm oil. (Refer to your Handbook for specifics.)

Take-Off and Climb

- Follow your checklist.
- Use full throttle (with few exceptions).
- Mixture full, rich, except at high density altitude airports where you should lean, as appropriate. (Refer to your Handbook for specifics.)
- Use 75 percent power for climb.
- Climb at higher than normal airspeeds on hot days to improve engine cooling.
- Lean the mixture during climb to the specified fuel flow or for smooth operation above 5000 feet density altitude.

Cruise

- Set 65 to 75 percent power for best performance.
- Set 55 percent power for best economy and range.
- Lean the engine in accordance with the instructions in your Handbook for your specific aircraft.

Descent and Landing

- Avoid over-cooling. Maintain sufficient power to keep engine temperatures "in the green."
- Gradually enrich the mixture for smooth engine operations as you descend.
- Keep cowl flaps closed.
- Set mixture "full rich" before landing UNLESS LANDING AT A HIGH DENSITY ALTITUDE AIRPORT. For operation into and out of high altitude airports, consult your Handbook.

Use of Carburetor Heat

- Carburetor heat should be used whenever atmospheric conditions indicate icing is a possibility and the engine is being operated at 75 percent power and below.
- When using Carburetor heat, always use full heat.
- After applying Carburetor heat lean mixture for smooth operation Reason: the warm intake air is less dense and produces a richer mixture.

IN SUMMARY

- Follow the procedures in your Pilot's Operating Handbook—"Know'em Cold."
- Comply with all engine and airframe manufacturers service bulletins, letters, etc.

- Use your checklist.

Part II—HOW TO LEAN DIRECT DRIVE NORMALLY ASPIRATED ENGINES

by

AVCO Lycoming

DEFINITIONS:

- Direct drive means that the propeller is bolted to, and turns at the same speed as, the crankshaft. No reduction gearing is used.
- Normally aspirated means that the engine has no supercharger or turbocharger to maintain sea level atmospheric pressure at higher altitudes and, therefore, its maximum available power decreases with altitude.

THEORY:

Fuel flow through either a carbureted or fuel injected induction system must be adjusted manually, in almost all instances, to provide for the most efficient fuel to air ratio for efficient combustion within the cylinders. Given certain fuel to air mixtures, it's possible to have a situation where the engine will run rough—or will not run at all. Since air density varies with temperature and altitude, it's important to understand when and how to adjust the mixture control to obtain the best performance, fuel economy and maximum life from your engine. Figure 1 illustrates the effect of leaning on cylinder head temperature (CHT), exhaust gas temperature (EGT), engine power and specific fuel consumption for a typical engine at constant engine RPM and manifold pressure. Study this simplified figure carefully. The key point to be gained from this chart is that there is an optimum fuel to air mixture setting at which to achieve either "best economy" cruise or "maximum power."

WHY LEAN?

You should lean the mixture for:

- Improved engine efficiency.
- Greater fuel economy (i.e., minimum specific fuel consumption) and longer range that's a safety factor. Also, saving fuel is in the national interest.
- Smoother engine operation—saves engine accessories and engine mounts.
- Longer spark plug life, less fouling. This is a safety of flight item, and saves dollars.
- Reduced maintenance costs.
- Reduced operating costs.
- More desirable engine temperatures, while operating at cruise altitudes.

WHEN TO LEAN:

- Lean anytime the power setting is 75% or less at any altitude. (Full throttle or climb power through 5000 feet density altitude usually means mixture full rich.)
- At high altitude airports, lean for taxi, take-off, traffic pattern entry and landing.
- For landings at airports below 5000 feet density altitude, adjust the mixture for descent, but only as required—
  —You can't go wrong if you keep the engine running smoothly.
  —Before entering the traffic pattern, go to full rich.
- In any event, always consult your Pilot's Operating Handbook for the proper leaning procedures.
- Note—You might have to lean when carburetor heat is being applied. Reason: The warmed intake air is less dense and produces a richer mixture.

HOW TO LEAN:

Tachometer Method: (For use with fixed or variable pitch propellers.)

Set the controls for the desired cruise power setting as shown in the Handbook. Then, gradually lean the mixture from full rich until the tachometer reading peaks. In smooth air, you should also notice a slight increase in aircraft speed. At peak RPM, the engine is operating within the maximum power range. For best economy operation, the mixture is first leaned from full rich to maximum power, then the leaning process is slowly continued until the engine starts to run rough. Then, enrich the mixture sufficiently to obtain a smooth firing engine. Obviously, some engine power and airspeed is sacrificed when operating at best economy. What you gain, however, is increased endurance.

Engine "Rough" Method: (For use with fixed or variable pitch propellers and engines equipped with float-type Carburetors only.)

With this method, you first set the throttle to the appropriate power setting, (75% power or less), then lean the engine gradually until the engine starts to run rough, then enrich the mixture slightly until the engine is again running smoothly. You will then be operating near the "best economy" mixture setting.

Fuel Flowmeter Method: (For use with any type propeller.)

The Handbook for aircraft equipped with fuel flow gauges contains appropriate fuel flow settings or, alternatively, the fuel flow gauge may be marked for correct flow at each power setting. You need only lean the mixture to the published or marked fuel flow values to achieve the correct mixture.

Exhaust Gas Temperature (EGT) Method: (For use with any type propeller.)

Figure 1 shows that the peak EGT occurs essentially at the rich edge of the best economy mixture range. It further shows that operation at peak EGT not only provides essentially

minimum specific fuel consumption but, also, 95 to 96 percent of the engine's maximum power capabilities for a given engine speed and manifold pressure. In addition, engine operation is very smooth at peak EGT. In comparison, a very noticeable power loss or roughness will occur when the engine is operated at the lean side of the best economy range.

HIGH ALTITUDE OPERATIONS:

At high altitude airports (5000 feet density altitude and above), lean for taxi, takeoff, descent and landing.

- On startup and taxi, lean at 1000 RPM (all propeller combinations) until RPM peaks, then enrich slightly.
- Before takeoff—go to full throttle and lean mixture.
  —With a fixed pitch prop, lean to maximum RPM, then enrich slightly.
  —With a variable pitch prop, on carbureted engines, lean to engine smoothness. If you have an EGT gauge, lean to +100°F on the rich side of peak.
  —Fuel injected engines—lean to the correct fuel flow setting according to your Pilots Operating Handbook.
- Always lean at traffic pattern altitude for landing at high altitude airports but only after maximum power has been established. This will insure maximum available power in the event that a go-around is necessary.

SUMMARY:

If your aircraft is equipped with the following propeller/EGT/fuel flow indicator combinations, lean according to the following chart:

Propeller/Fuel Flow/EGT Combinations	Lean Using the Following Methods
Fixed or variable pitch propeller with no EGT and no fuel flow indicator.	Tachometer method, or engine "rough" method.
Constant speed propeller with no EGT and no fuel flow indicator.	Engine "rough" method.
Any type propeller with fuel flow indicator.	The settings published in your Handbook, or marked on the fuel flow indicator.
Any type propeller with EGT gauge.	Set EGT according to the Handbook, usually peak EGT, then enrich slightly to smoothness.
Any type propeller with fuel flow indicator and EGT gauge.	First adjust to the fuel flow setting as published in the Handbook, then lean by

	setting the EGT according to the Handbook.

SYNOPSIS:

Always follow the engine operating procedures provided by the aircraft manufacturer for your aircraft in the "Pilot's Operating Handbook."

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