



# **Engine Break-in Instructions *and Oil Management***

## **For Engine Overhaul or Cylinder Replacement**

### Includes Sections on:

- Contamination
- Cylinder Bore Materials
- Filtration
- Fuel
- Lubrication
- Oil Content Reports
- Oil Pressure
- Over-Servicing
- Pre-Oiling



**ENGINE COMPONENTS INTERNATIONAL**

## **Engine Break-in Instructions and Oil Management**

**For Engine Overhaul or  
Cylinder Replacement**

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# Engine Break-in Instructions and Oil Management

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NOTE: In the interest of presenting real-time information to the operators of piston engine aircraft, the following comments from RAM Aircraft are offered. Engine Components International (ECi<sup>®</sup>) views RAM's service data as a further refinement of ECi's endorsement of Phillips 66 aviation oils.

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# Oil Talk for Dummies

AD:	Ashless dispersant.
Additives:	Any compound added to oil for the purpose of improving the performance of the oil.
Approved Aviation Oil:	Approved Aviation Oil - any brand name oil produced under the following specifications:  MIL-L-6082 or SAE J1966 for Mineral Grades  MIL-L-22851 or SAE J1899 for Ashless Dispersant Grades  <b>CAUTION:</b> Some approved oils contain anti-scuffing additives that should NOT be used during engine break-in. Always refer to the label to ensure that the oil is correct for your application.
Ashless:	When burned, does not form a metallic ash which could be a source of pre-ignition.
Blending:	The process of mixing oils to obtain the desired consistency. <b>NOTE:</b> Blending should be contrasted with compounding which involves additives.
Boundary Lubrication:	A condition of lubrication in which the friction and wear between two surfaces in relative motion are determined by the properties of the surfaces and by the properties of the lubricant other than bulk viscosity.
Detergent:	A cleaning additive; a metallic compound to protect from sludge and varnish build-ups. Detergents are not allowed under MIL-L-22851 or MIL-L-6082. No current aviation oil contains detergent compounds.
Dispersant:	Suspends wear metals and contaminants in the oil until they can be filtered or drained. Has no adverse affect on Break-in.
EP Lubricants:	“Extreme Pressure” lubricants have additives that provide boundary lubrication to mating metal parts when a film of oil is not present. The additives are compounds of chlorine, phosphorous and sulfur which react with metal parts in the engine to form protective films and polish mating parts.
Hydrodynamic Lubrication:	A system of lubrication in which the shapes and relative motion of the sliding surfaces cause the formation of a fluid film that has sufficient pressure to separate the surfaces.
Micron (µm):	A unit of measure = $4 \times 10^{-5}$ inches.
Mineral Oil:	Oil separated from crude oil according to boiling points.

**Multi-viscosity:** Oil that pours like a low viscosity oil at low temperature, but is similar to higher viscosity oil at operating temperature.

**NOTE:** The advantage is quick pumping at start-up, performance identical to a higher viscosity oil at moderate temperatures and a thicker film at high temperature.

**SAE Grade:** System used by engine manufacturers to define the lubricating oil requirements for their engines.

SAE Viscosity Vs.	SAE Viscosity	MIL Aviation Grade
	30	65
MIL Grade:	40	80
	50	100
	60	120

**Scuffing:** Severe adhesive wear resulting from metal transferring from one surface to a mating surface due to solid phase welding or abrasive effects between sliding surfaces.

**Sludge:** A coagulated mass, often containing foreign matter, formed at low temperature in piston engines from oil oxidation residues, carbon, and water.

**Synthetic Oil:** Produced by chemical synthesis of compounds reacting with other chemicals to have characteristics similar to mineral oil.

**TCP:** Tricresyl Phosphate. An oil additive which produces an EP lubricant. Lycoming oil additive LW-16702 contains this chemical.

**VI Improver:** Viscosity Index Improver blended with medium viscosity oil to better control its viscosity at higher temperatures.

**Viscosity:** Measure of liquid resistance to flow.\*

**W (e.g. 25W):** Grade numbers followed by the letter W (i.e. 5W, 10W, etc.) identify oils suitable for winter service. Viscosities for those oils are determined at various cold temperatures on a Laboratory Cold Cranking Simulator (CCS) and Mini Rotary Viscometer (MRV), and are reported in centipoise (cP). Numbers without the W (i.e. 20, 30, etc.) identify oils for higher temperature (summer) service.

\*RAM service history indicates that Mineral Based AD oils perform significantly better than synthetic and semi-synthetic oils.

# Critical Precautions for New and Overhauled Engines

Airplane owners, builders of aircraft engines, and component suppliers such as Engine Components International (ECI®) have a mutual interest in engine break-in. All want the engine to perform and give long and satisfactory service life.

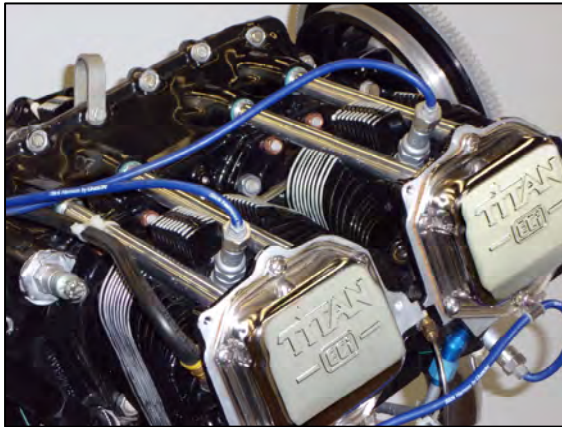
**CAUTION:** If your engine has been carefully overhauled to airworthiness standards, it should provide excellent service if certain steps are taken by the mechanic making the installation and the pilot(s) operating the airplane. Following is a list of causes for an aircraft engine to fail early in service, and suggested procedures to optimize operating life and safety.

When an engine fails to give satisfactory service, it is frequently due to: unseated piston rings due to improper break-in, uneven cooling due to improper baffling, poor fuel distribution, incorrect timing, damaged or perforated piston heads caused by detonation or preignition, piston scuffing or seizing usually caused by overheating or unseated rings that allow blow-by to displace the oil film between the piston and cylinder bore, bearing and crankshaft wear caused by under-lubrication or dirt, excessive piston and cylinder wear caused by dirt, ineffective air filtering or excessively rich or lean-air fuel mixture.

We Strongly Recommend These Precautions:

1. Pressure oil the engine before the first start-up after the engine has been installed in the airplane. There are numerous systems that will accomplish this task, which range from homemade to sophisticated production equipment.  
Unfortunately, pressure oiling does not lubricate cylinders, pistons, and rings. Therefore, ECI recommends that spark plugs be removed and the cylinders themselves should be oiled before start-up. If the engine is equipped with a spin on type oil filter, it is beneficial to fill the oil filter with engine oil before start-up. The filter must be properly installed, torqued and safety-wired. All pre-oiling equipment and activities must be maintained and performed in a manner that does not introduce contaminants into the engine.
2. Proper air-fuel ratio is vital in today's engines. Be sure the carburetor or fuel injection system meets the manufacturer's specifications. Air seepage in the intake system can cause lean air-fuel ratio which causes detonation. A defective compressor in a turbo charger can produce excessively hot air to the cylinders which reduces the combustion detonation margin, inhibit cylinder break-in, increase blow-by, etc.
3. The ignition system supplied with the engine should be checked and the system tested. Particular attention to the points and "E" gap setting is warranted. Magneto timing to the engine should be set and verified according to approved data.
4. Be sure to use spark plugs of the correct heat range and gap as specified by the engine manufacturer.
5. Check all fuel and oil lines for security and leaks. All hard lines must be adequately supported to prevent fatigue. Make sure that check valves are installed properly. Insure that heat protection for the fuel and oil lines is correctly installed.

6. **NOTE:** Do not put Textron Lycoming oil additive P/N LW-16702 in O-320H and O/LO-360E engines for break-in. This oil additive will inhibit break-in so it should only be added after break-in has occurred. (See Lycoming S.I. No. 1014M Part II.B)
7. **IMPORTANT:** Replace oil filter or check and clean oil screen. Thoroughly check all engine accessories and installation.
8. Always preheat the engine in weather 30°F or less.
9. Always use caution around the propeller.
10. Heat is both the source of power and the enemy of an engine and is definitely worse during the early stages of break-in. Careful inspection, adjustment, repair, etc. of the cooling system (cowling, baffles, etc.) is essential for every new installation or top overhaul.
11. Should you encounter problems, refer to ECI Service Instruction No. 89-5-1, "Engine Trouble Shooting Guide" at <http://www.eci.aero/servicedocs>.





## Run-in vs. Break-in

Typically, most engine overhaul shops run-in all opposed engines for a period of one to two hours prior to release for installation. However, this run was never intended to be a break-in run. The objective of the run-in test is to:

1. Prove that the engine will produce rated power.
2. Correct any oil, fuel, or induction leaks.
3. Check general operation of the fuel system.
4. Allow engine oil pressure to be set.
5. Provide initial stage of break-in.

After run-in, the engine is released to the installer who deals with installation, baffling, fuel settings, additional break-in and other unique considerations which can only be dealt with on the actual airframe where this engine is to operate.

We recommend these procedures to run-in an overhauled engine in a test cell or when using a properly designed shroud similar to the one shown in the photograph on the next page:

**NOTE:** The following information applies to all types of cylinder bores:

STEEL/CAST IRON - Plain, nitrided, through hardened  
CHROME - Porous, silicon carbide impregnated  
NICKEL COMPOSITE - CermaNil™ process or Nickel+Carbide™

1. Regardless of technique used, the major consideration during run-in is adequate cooling of the cylinders and oil. Inter-cylinder baffles must be used to assure that the cylinders are cooled on the downwind side as well as the side facing the cooling air. The shroud and baffles must be appropriate to the type engine and propeller to be used. Test club type propellers are generally much shorter than flight propellers, and force the air close to the engine. When using a flight propeller for run-in, the shroud should be much taller to capture as much cooling air as possible.
2. Forced air cooling systems used with dynamometers must provide all the cooling air required during the run-in test and should be able to maintain cylinder temperatures below 400°F (204°C) at any point in the process. Intercylinder baffles are normally required, and the cooling system should be capable of maintaining at least 6 inches of water static pressure differential between the cooling air intake and outlet.
3. Engine operation parameters for test cell run-in are provided in the engine manufacturer's overhaul and service data. ECI recommends that the operator follow the procedures established for the specific type of engine being tested.\*

**\*CAUTION:** The operator should be aware that the porous type chrome plated cylinder bores have more critical cooling requirements than other cylinder bore surfaces.

ECI recommends the use of a test stand or cell with appropriate test clubs and shrouds or forced air cooling. However, carefully followed procedures can provide adequate run-in on an airplane. We must caution, however, that run-in on an airplane entails some risk that should be considered by the overhauler/installer. In

addition to the risk due to test flying, overheating the engine on the ground must be considered by the overhauler/installer. In some cases of extreme engine overheating, the pistons will expand to a diameter larger than the cylinder bore, and will result in severe scoring. ***Overheating of the cylinder barrel during run-in is not always indicated on cylinder head temperature gauges before the damage has been done because the thermocouple is on the head rather than the barrel.*** Improper ring seating causes increased blow-by which heats the internal components of the engine and the oil supply. Prolonged operation with excessive blow-by can cause premature failure of cam followers and camshaft lobes.



*Example: Run-in using cooling shroud*

We recommend these procedures to run-in an overhauled engine installed in an airframe:

**NOTE:** The following information applies to all types of cylinder bores:

STEEL/CAST IRON - Plain, nitrided, through hardened  
CHROME - Porous, silicon carbide impregnated  
NICKEL COMPOSITE - Cerminil™ process or Nickel+Carbide™

1. Assure that all precautions contained in the section entitled "Critical Precautions" have been observed.
2. Each cylinder should be instrumented to measure temperature.
3. Head aircraft into the wind for ground runs.
4. Limit initial run to three minutes. Hold initial engine RPM to 1200 to obtain oil pressure, and then increase to 1800 RPM to minimize cam lobe stress. If oil pressure is not obtained within 30 seconds, shut down and investigate cause.
5. Allow engine to cool (below 100°F CHT), and repeat short runs up to 2000 RPM to assure discrepancies are corrected. Note that low RPM increases stress on cam lobes. Under no circumstances should high power be used to adjust fuel flow (flight without proper fuel flow is damaging to the engine). Engine runs should be limited to three minutes when using porous chrome plated cylinders.\* Runs on all other cylinder types should be limited to four

minutes to prevent overheating. While performing ground runs, do not permit cylinder head temperatures to exceed 400°F or oil temperature to exceed 200° F. During the last run before flight, a short full power application of 10-20 seconds is advisable to assure take-off power is available. An idle mixture check is also advisable (reference the appropriate engine overhaul/service data).

**\*CAUTION:** The operator should be aware that the porous type chrome plated cylinder bores have more critical cooling requirements than other cylinder bore surfaces.

6. The engine installation should be thoroughly inspected prior to the first flight. Fuel and oil leaks should be corrected and all baffles and cowling should be reinspected. The oil should be checked to assure that blow-by has not darkened it excessively, and to verify the quantity.
7. Cycling the propeller can place unnecessary stresses on the cylinders, and should be minimized prior to first flight. We recommend that the propeller be cycled sparingly, and only to verify that oil has filled the propeller dome and propeller control has been achieved.
8. Initial flight when OAT is above 90°F is not recommended.
9. Keep aircraft weight to a minimum. Only required crew should be aboard the airplane for the test flight.
10. On take-off, use minimum power to reach 40 MPH (IAS) before applying required take-off power. CAUTION: Determine that there is sufficient runway remaining in order to reach take-off airspeed.
11. Use take-off power only as long as necessary to get to BEST CLIMB SPEED. Reduce manifold pressure to minimum required for clean in-flight attitude. Leave propeller in flat pitch for at least 5 minutes after take-off. For aircraft not equipped with a variable pitch propeller or manifold pressure gauge, reduce power to 75%. Use minimum rate of climb with maximum air speed consistent with terrain.
12. When desired altitude is reached and cylinder head and oil temperatures are satisfactory, aircraft should be operated at 75% power until 20-30 minutes of flight time have elapsed. The engine should then be operated at various power settings and engine operating parameters observed until at least 45 minutes of flight time have elapsed. All power changes should be made very gradually, especially power reductions.
13. During the test flight, any time that a persistent high oil or cylinder head temperature is noted, a precautionary landing and inspection should be made to determine the cause. Maximum permissible cylinder head temperatures are published in each specific engine's type certificate data sheet. These maximum permissible temperatures range from 450°F to 525°F, depending on the engine type. Consult your specific engine's type certificate data sheet for maximum operating temperature.
14. On initial flight after at least 30 minutes of satisfactory flight time have been accumulated, the aircraft should be landed and the engine be reinspected. Oil consumption should be noted; and, if excessive, should be investigated before further flight.
15. Test flight and results should be entered in the engine log books before the airplane is released to service. Operators should be cautioned against long ground runs and prolonged climbs at low air speeds.

16. Ground operations and continuous climb at low airspeed should be minimized until the engine has accumulated at least 25 hours operating time. Cylinder overheating can cause cylinder bore glazing and/or piston scuffing at any time during engine operation but cylinder assemblies are most susceptible to these problems during the first 25-50 hours of operation. Whenever glazing and/or scuffing become severe, the only remedy is to remove the offending cylinder(s), mechanically remove the glaze, replace the piston if necessary and install a new set of rings.

## Fuel for Run-in and Break-in

**IMPORTANT:** Use only 100LL for engine run-in and break-in for an engine that was designed, tested, and certified on 100LL or 80/87. Under no circumstances should unleaded auto gas (mogas) be used when breaking in an engine.

### Facts:

Lead in fuel serves as a lubricant, raises the octane rating and serves as a cushion for the valve/seat interface.

Most STC's, e.g. Peterson, for use of auto gas (mogas) in a certificated engine exclude the use of auto gas during the run-in and break-in process.

**Discussion:** Aircraft piston engine valve seats, especially the exhaust, operate at much higher temperatures than automotive, motorcycle or other altitude challenged motors. Elevated temperatures present three challenges to the design requirements for exhaust valve seats, 1.) the oxidation resistance of the material must stand up to the harsh environment created by exhaust gases, 2.) the coefficient of expansion for the material must be close enough to aluminum so that the seat does not fall out, and 3.) the material must resist micro welding to the valve face when the valve closes on the seat. These three requirements severely limit the number of candidate materials from which to choose. A common characteristic of all of the candidates, however, is that they have a high nickel content, a material that forms a spongy oxide on the surface at elevated temperatures.

In the early days of air-cooled aircraft engine design, it was discovered that the spongy oxide absorbs lead that is left behind from the combustion of leaded fuel. The oxide matrix filled with lead forms a layer that not only cushions the valve face when it closes on the seat but also serves as a high temperature lubricant so the seat and valve face do not weld together. When the nickel oxide layer is not filled with lead, premature wear of the seat is a high probability. It is extremely important to have lead present in the combustion chamber during the initial hours of operation if the design life of the cylinder is to be realized. This is especially true for higher compression ratio or turbocharged engines. Once the lead/oxide layer has been created during run-in and break-in, it will maintain itself reasonably well even if auto gas is burned for several fill-ups. Based on experience, ECI strongly recommends the use of leaded fuel at least every few tanks so that the lead/oxide layer is maintained. The higher the compression ratio, the more important the use of leaded fuel becomes.

On the other hand, lower compression engines are plagued by lead compound build-ups in the valve guides that can lead to valve sticking. The 80-87 fuel these engines were designed to use is not universally available, and some of the available 80-87 fuel has zero lead content. The original version of this fuel had up to .5 ml/gal of tetraethyl lead, which was just about right for these engines. The 2 ml/gal of tetraethyl lead in 100LL fuel is a real challenge for engines like the C-85, O-200, or O-235.

Auto gas (mogas) has greater variables for chemistry, vapor pressure, contaminants, etc. which change with locale and season. It is not a source controlled product such as aviation gas. The adverse effects for aircraft piston engines that can be attributed to auto gas are well documented by gasoline companies and ECI as well as the engine manufacturers caution all owner

operators to use auto gas only with full knowledge of the problems, appropriate care, and consideration of possible limits to warranty.

**ECi's Limited Warranty for the use of auto gas:** In the event a warranty claim is made, ECi reserves the right to deny the warranty claim if, in their sole judgment, the defect or problem giving rise to the claim resulted from the use of auto gas.

# Oil Recommendations

*(Courtesy of RAM Aircraft, LP, Waco, TX)*

## Oil Viscosity

Points made are well taken on both sides of the issue of whether to use single or multi-grade oils. In the final analysis, you know that your aircraft is subjected to extreme temperature variations and starting conditions. Many aircraft fly frequently. Many aircraft don't fly enough. Successes (and lack of) suggest there is simply not one viscosity that is always the best for all flight environments. RAM sees the following:

- Multi-Viscosity Mineral Based (AD) oil is working well in higher usage airplanes.
- Single Viscosity Mineral Based (AD) oil is working well in lesser-flown aircraft.

## Synthetic & Semi-synthetic vs. Mineral Based Oil

RAM service history records are much less favorable for engines that have a history of being operated on synthetic blends or semi-synthetic oil products. RAM encourages using Mineral Based (AD) Oils only - single or multi-viscosity, as conditions require.



# Warning - No Oil Pressure - No Engine

*(Courtesy of RAM Aircraft, LP, Waco, TX)*

1. New and overhauled aircraft piston engines are subject to oil pressure anomalies, primarily due to loss of prime that normally occurs after one of these conditions:
  - Engine installation
  - After oil change
  - After periods of inactivity
  - After major weather changes
2. After an engine installation, oil pressure must be established on the engine prior to the initial start up.
3. Attention should always be paid to oil pressure coming up at every engine start...within 15 to 20 seconds.
4. Extreme attention must be paid when the above-mentioned conditions exist in order to avoid internal damage and ultimate failure of the engine.
5. Pre-oiling with a pressure pot is highly recommended. With the spark plugs removed, turning the engine through with the starter is also an acceptable method, but use extreme caution around the moving propeller.
6. **NOTE:** Bleeding the oil line from the engine to the oil pressure gauge at the fitting will help the gauge show real time pressure much quicker. While running the engine, have an assistant catch the residual oil in a cup at the gauge end.



## Lubrication for Run-in and Break-in

**NOTE:** The following information applies to all types of cylinder bores:

STEEL/CAST IRON - Plain, nitrided, through hardened  
 CHROME - Porous, silicon carbide impregnated  
 NICKEL COMPOSITE - Cerminil™ process or Nickel+Carbide™

The lubrication demands imposed upon your engine during run-in and break-in period are different from its operational needs.

During run-in and break-in your lubricant should:

1. Provide immediate oil flow and pressure for start-up protection.
2. Provide protection against extreme temperature changes.
3. Eliminate oil related by-product deposits.
4. Suspend contaminants.
5. Enhance the engine's break-in processes.

Phillips SAE20W-50 multi-viscosity oil provides quick lubrication for improved start-up with the SAE20W low temperature viscosity. All multi grade oils lubricate three times faster than straight weight, yet its full bodied SAE 50 viscosity will completely protect the engine at high temperatures and operational loads. The ashless dispersant (AD) in this oil keeps your engine's lubrication system free from oil related contaminants. The dispersant additive further enhances the system by suspending contaminants and operational wear metals in solution rather than allowing them to settle to the bottom of your crankcase forming harmful engine sludge. Finally this 100% mineral product will enhance the mating of all the parts involved in systems requiring operational wear-in.

For your convenience and future reference we recommend the following lubrication schedule (Without filter reduce intervals to 25 hours or 3 months whichever comes first):

Hours on Overhaul	Description	Lubrication Package
0	Initial fill-up	Phillips X/C SAE 20W50
10	Change Oil and Filter	Phillips X/C SAE 20W-50
35	Change Oil and Filter	Phillips X/C SAE 20W-50
60	Change Oil and Filter	Phillips X/C SAE 20W-50
Every 50 Hrs. or 3 Months	Change Oil and Filter	Phillips X/C SAE 20W-50 is recommended.

**NOTE:** Should you ever need to change out a cylinder **you will not need to switch to a mineral oil for break-in.** Since Phillips X/C20W-50 is 100% mineral it will ensure the break-in process for newly installed cylinder(s).

# Lubrication for Normal Operation

**NOTE:** The following information applies to all types of cylinder bores:

STEEL/CAST IRON - Plain, nitrided, through hardened  
CHROME - Porous, silicon carbide impregnated  
NICKEL COMPOSITE - Cerminil™ process or Nickel + Carbide™

Air-cooled aircraft engines typically encounter far more stress and strain than any other kind of reciprocating engines. Therefore, the operational lubrication needs are four-fold.

Reduced to its simplest tasks, oil has four major functions: to lubricate, to suspend dirt and wear particles between oil changes, to aid in cooling, and to seal, thus it offers protection against heat, pressure, corrosion, oxidation, and contamination.

Oil in piston aircraft engines must work in an environment that is radically different from those found in automobile, industrial, and agricultural engines. One major difference is that aircraft engines are air-cooled.

Air cooling has evolved as the simplest and most effective method of regulating engine and cylinder temperatures in an aircraft engine, which must operate in extremes of altitude and temperature. While it provides lighter weight and less complexity in its systems, an air-cooled aircraft engine typically sees a wider range of temperature than its liquid-cooled counterpart.

The widely varying operational boundaries experienced by aircraft engines dictate that components for their oils be different from those used in other applications, and the best way to understand their roles is to review the evolution of aviation oil.

## Early Aviation History . . .

Although automotive history predated aviation by only a few years, the mass availability of the automobile demanded that lubrication of its engines match the on-going improvements in powerplant efficiency, reliability, and life span. But until the closing years of World War II, aviators were relegated to using virtually the same straight-grade mineral oil as the Wright brothers had used. Practically the only research and development being done then for piston-powered aircraft engine oil was by aviation's biggest customer, the military. They developed the oil specifications that were also generally accepted in civil aviation.

These specifications, MIL-L-6082 (straight grade) and MIL-L-22851 (multi-viscosity) were established in 1944 and 1961.

Given FAA and manufacturer acceptance of military standards and the operational requirements for aviation oils, ECI confidently recommends Phillips 66 X/C Aviation Multi-viscosity Oil SAE20W-50.

**CAUTION:** Do not use any oil containing anti-scuffing additives during break-in.

Using an oil formulation of multi-viscosity and ashless dispersant will reward your engine with the following benefits:

- a. It assures lubrication and engine protection with the extreme temperature changes encountered in cross country flight.
- b. It provides ashless dispersant type multi-viscosity aviation oil for aircraft piston engines, both opposed piston or radial types.

- c. While SAE20W low temperature viscosity offers improved start-up with quick lubrication, full-bodied SAE50 gives complete protection at high engine temperatures and high load operations.
- d. It minimizes engine-related flight problems of deposit induced pre-ignition and spark plug fouling, and also reduces troublesome piston, rocker box, and crankcase deposits.
- e. It is approved by Teledyne Continental Motors specification MHS-24B, Textron Lycoming Specification 301F, Pratt & Whitney Bulletin No. 1183 (Revision "S"); and the additive treatment package meets the performance requirements of MIL-L-22851C.
- f. It is compatible with other approved aircraft engine oils.

**CAUTION:** Do not use any oil containing anti-scuffing additives during break-in.

# Break-in Procedures

(First 100 Hours)

A new or overhauled engine is an expensive investment. Break-in is the most important time in the life of your engine and is critical in determining its performance capability. Seventy-five (75%) percent of the total normal wear of an engine occurs during the break-in period. According to Federal-Mogul (the leading authority for engine bearings throughout aviation's development era) new piston rings, pistons, and refinished cylinder bores will be more sensitive to break-in than any bearings. Any break-in procedure acceptable for rings and bores will be agreeable to the bearings. Therefore, the first consideration in the break-in mode should be to accomplish the ring to bore seating.

The operator should become informed about the type of ring faces and cylinder bore materials which are installed on the overhauled engine. The value of the information lies in two areas, 1.) the susceptibility to overheating, and 2.) the time in the break-in period when oil consumption will most likely stabilize.

Porous chrome plated cylinder bores are the most susceptible to overheating. Depending on the grade of cast iron used in the top compression ring, the degree of taper on the face of the ring, the ring tension, the geometry of the cylinder bore, ring finish and a great many other factors, experience has shown that porous chromium is the least forgiving. Therefore, proper break-in procedures must be followed if optimum oil consumption levels are to be realized over the life of the engine. On the other hand, cylinder bore surfaces other than porous chrome, i.e. steel, impregnated chrome, Nickel+Carbide™ and Cerminil™ process, can tolerate some deviation from ideal break-in conditions and still give exceptional performance.

While ring to bore seating will normally take place within the first several hours of operation, optimum oil consumption is frequently not achieved until 50 hours or more of operation have been accumulated. However, there are times when cylinders will glaze or prematurely lose their ability to "grind-in" the ring face. This condition is usually marked by lack of any reduction of oil consumption (oil is usually found on the belly of the airplane due to a pressurized crankcase) during the first 10 hours of operation. By removing the spark plugs and checking for fouled electrodes, the offending cylinder(s) can be identified. The recommended remedy is to remove the cylinder(s), rehone the bore for ring finish and reinstall using new rings.

**CAUTION:** The operator should be aware that the porous type chrome plated cylinder bores have more critical cooling requirements than other cylinder bore surfaces.

There are many techniques that have been advocated to enhance break-in or rejuvenate porous chromium plated cylinders over the years. We do not recommend any techniques beyond the procedures put forth herein.

We recommend these procedures to break-in a new or overhauled engine:

**NOTE:** The following information applies to all types of cylinder bores:

STEEL/CAST IRON - Plain, nitrided, through hardened  
CHROME - Porous, silicon carbide impregnated  
NICKEL COMPOSITE - Cerminil™ process or Nickel+Carbide™

1. Verify that the engine has been run-in (See the section entitled "Run-In vs. Break-in.") If this procedure has not been performed, follow run-in

instructions contained in the section entitled “Lubrication for Run-in and Break-in.”

2. Assure that all precautions contained in the section entitled “Critical Precautions for New and Overhauled Engines” have been observed.
3. For the initial flight, fast idle (850-1,000 RPM) engine for three to four minutes. Shut down and inspect for oil leaks. During ground runs, do not permit cylinder head temperatures to exceed 400°F or oil temperature to exceed 200°F.
4. Start engine, run up normally, taxi, and take off immediately. (Minimize ground time.) Reduce manifold pressure as soon as practical. Slowly reduce engine speed to maximum continuous RPM (top of green) for fixed pitch propellers, reduce power to 75%.
5. Cycle the propeller before flight only enough to verify control. This will ensure the propeller hub has oil pressure prior to take-off.
6. Maintain a shallow climb to keep cylinder head temperatures as low as possible. Maximum permissible cylinder head temperatures are published in each specific engine’s type certificate data sheet. These maximum permissible temperatures range from 450°F to 525°F, depending on the engine type. Consult your specific engine’s type certificate data sheet for maximum operating temperature.
7. Level off at altitude and maintain 75% power for at least 30 minutes. During the first 50 hours of the break-in period, piston rings will seat best if cruise is maintained at 65% to 75% power. Oil consumption will also be optimized under these operating conditions. Normal ground idle may be used after the engine temperatures and oil consumption have satisfactorily stabilized.
8. Keep flying weight to a minimum to reduce power requirements during take off.
9. Follow break-in lubrication procedures in the section entitled “Lubrication for Run-in and Break-in.”
10. Should you encounter problems, refer to ECI Service Instruction No. 89-5-1, “Engine Trouble Shooting Guide” at <http://www.eci.aero/servicedocs>.

# Avoid Over-Servicing Engine Oil

(Courtesy of RAM Aircraft, LP, Waco, TX)

## **TSIO-520 & GTSIO-520 Engines**

If soon after shutdown you add oil to your engine in an effort to get the oil quantity/level indication back up to the full mark on the dipstick, you will most likely be over-servicing your GTSIO-520 or TSIO-520 engine and in some cases, by as much as two quarts. At such a higher oil level, during your next flight the crankshaft accessory drive gear (that projects below the top of the oil surface in the oil pan) will revolve through the surface of the oil and make vapor. The vapor will exit through the oil breather system and thus be spread over areas of the aircraft. To avoid such mess and reduce the anxiety of blowing oil vapor overboard, (concerned that you are using oil), these six oil-servicing guidelines should be followed:

1. Aircraft should be as level as possible when checking the oil. Use the same level area, as often as practicable, when checking oil at your home airport.
2. Properly install the right-hand dipstick in the right-hand engine, and the left-hand dipstick in the left-hand engine. There is a difference between the two--allowing calibration for the different engine cant angles.
3. Note and mark the dipstick's top orientation after properly servicing the engine with a known quantity of oil. Maintain that orientation throughout future oil checks. Readings can vary by as much as 1/2 quart simply by having the dipstick's orientation 180° in error.
4. Calibrate each dipstick. Immediately after draining the oil completely, add back your normal operational quantity of oil; for example, 10 quarts. Insert the dipstick and note the oil level indicated. Often off as much as one or two quarts, the dipstick may indicate 8.5 quarts. In the future, remember that such 8.5 quarts level represents the 10 quarts level.
5. Measure oil drain-down quantity. Do so by measuring the oil quantity immediately after shut down, then again 12 hours later. Note the increased indication of oil level after the 12-hour period--typically due to oil draining from the oil filter, the oil cooler, and engine oil passages.
6. For long flights, especially over water, service the engine to its full capacity. Knowing that at full capacity some oil will be blown overboard, expect to wipe off the airframe accordingly without becoming anxious about seeing excess oil.

# Cylinder Replacement

Cylinder replacement during the life of a first run or overhauled engine poses special run-in, break-in and lubrication problems. But it is a fact that the airplane operator must make choices from a rather lengthy list of options:

1. Should I replace just the faulty cylinder(s) or all of them (top overhaul)?
2. What cylinder barrel surface should be on the replacement cylinder(s)?
3. Can I use oversized replacement cylinders along with standard sized cylinders on the same engine?
4. If the reason for cylinder replacement is excessive guide wear, can I replace the valves and guides and put the cylinder back on the engine with the same piston and rings?
5. Should I change my oil and if so to what?

To give an informed answer to these questions requires knowledge of the specific situation because any of the foregoing questions can be answered “yes” or “no” depending on the facts. Therefore, we believe that most decisions are based on economics rather than technical considerations, a belief which is further strengthened by the fact that most cylinder replacements are unscheduled. Help with these questions can be obtained by dialing 1-800-ECI-2FLY and speaking with a Customer Service Representative or go to our website at: <http://www.eci.aero>

## Precautions:

1. While economics guide the cylinder replacement decision, every replacement cylinder must meet the airworthiness test. All cylinder repairs must be performed by the factory, by FAA certificated repair shops, or by FAA licensed mechanics. All replacement parts must be approved by the FAA and have traceability to their origin.
2. Properly identify cylinder(s) to be replaced and be sure to reinstall an exact replacement. The ECI Class Reference Manual is a good document to use for accomplishing this task. Visit ECI’s web site at <http://www.eci.aero> or call us at 800-ECI-2FLY for further information.
3. If the removed cylinder(s) is reinstalled, first determine the type of bore surface and then follow the appropriate installation steps described below:  
  
POROUS CHROME: Visually inspect the bore to be sure that channels are visible. If channels are not visible, the bore must be re-plated. Impart a ring finish to the bore and fit new rings to the piston.  
  
STEEL/NITRIDED/CAST IRON: Impart a ring finish to the bore and fit new rings to the piston.  
  
CermiNil™ Process or Nickel+Carbide™. Impart a ring finish to the bores using procedures contained in ECI Service Instruction 92-9-6, “Cylinder Removal and Reinstallation” or its subsequent revision. New rings must be fitted to the pistons.
4. Rings and bore surfaces must be compatible. **CAUTION:** Do not, under any circumstances, put chrome faced rings into chrome plated cylinder bores. Any orange paint on the outside of the cylinder is a good visual clue that the bore has been chrome plated. See ECI Service Instruction 94-4-1, “ECI Piston

Ring Sets - Applications, Fitting Instructions and Reference,” Rev. 18 or its subsequent revision.

5. Assure proper ring fit and gap. See Manufacturer's Overhaul Manual.
6. Cleanliness is imperative. Debris from applying the ring finish, gapping piston rings, grinding seats, reaming guides as well as airborne contamination can cause severe damage to the engine.
7. Lubricate bores, pistons, and rings with a properly formulated assembly lube.
8. Reinstall cylinder(s) in accordance with the manufacturer's recommended procedures.
9. We recommend that you not attempt to run-in replacement cylinders with oils containing synthetics or oils that do not have an ashless dispersant (AD) component. Synthetic oils will interfere with the ring and bore mating process which we want to occur as quickly as possible. Because the lower end of the engine is already well broken in, AD oils will keep debris from break-in in suspension so that it can be filtered out and not reach the critical bearing surfaces.

See ECI Service Instruction 92-9-6, “Cylinder Removal and Reinstallation,” Rev. 3 or its subsequent revision.

We recommend these procedures to run-in replacement cylinder(s):

1. Drain oil and replace with a multi-viscosity ashless dispersant (AD) oil such as Phillips X/C20W-50. **CAUTION:** Do not use any oil containing anti-scuffing additives during break-in. Install a new filter element.
2. Even when replacing one cylinder, the engine should be run-in according to recommendations contained in the section entitled, “Run-in vs. Break-in.”
3. Change oil and filter after 25 hours of operation and replace oil with Phillips X/C 20W-50.
4. Change oil and filter after the second 25 hours of operation and replace oil with Phillips X/C 20W-50.



# Stop Contamination During Engine, Propeller & Accessory Removal, and Installation

(Courtesy of RAM Aircraft, LP, Waco, TX)

1. Follow exactly the applicable STC and Service Manual procedures for installation.
2. Used propellers must be flushed thoroughly.
3. Propeller Handling
  - Do not leave un-installed propellers open.
  - Cap off all oil inlets and threaded studs.
  - Ensure blades are well protected.
4. O-ring Installation
  - Verify the o-ring is installed.
  - Lubricate groove area.
  - Install on crankshaft flange evenly.
  - Verify groove area is not cut or scored.
5. Crankshaft and Propeller
  - Verify clean and lubricated.
  - O-ring area smooth.
  - Do not allow prop attach studs to cut or bind in the crankshaft holes.
  - Torque up prop evenly per service manual or propeller placard.
  - Safety wire the studs on Hartzell props. Apply torque seal to studs and nuts.
6. Engine Installation Procedures
  - All re-used oil lines and hoses must be flushed.
  - The propeller governor must be flushed if re-used.
  - All other components such as the turbocharger, the turbo controller, the wastegate, and the air-oil separator canister must be flushed.
7. Engine RPM Fluctuations
  - If fluctuations occur, discontinue operation as soon as practical.

## Oil Filtration

High temperatures associated with normal air-cooled engine operation produce two contaminants which end up in lubricating oil: oxidation by-products and coke. In addition to combustion generated contaminants, the engine takes in a significant quantity of dirt by breathing it into the cylinders during engine operation.

The lubricating oil with an AD additive is very helpful in keeping the solid contaminants in suspension but when all of the AD is tied up with dirt and coke, additional contaminants introduced into the engine are free to deposit in unwanted locations. There are only two ways to prevent solid contaminants from depositing in the engine when the oil is overloaded:

- 1.) change oil
- 2.) install a filter

First, it must be said that a filter will do nothing to remove oxidation by-products, i.e. sludge, varnish, acids, and water. Water can be vaporized by operating the engine for sufficiently long periods of time to dry out the oil but liquid contaminants will pass right through a filter and remain in the oil no matter how good the filter media is on the filter. Draining the oil is the only way to get rid of the liquid contaminants.

Solid contaminant loading in the oil can be minimized with a full flow filter. While most aircraft piston engines come equipped with an oil screen, these screens have limited filtering efficiency. By pumping oil through a filter, particles are lodged in the filter thereby permanently taking them out of the system.

Data would suggest that a spin-on oil filter with the paper element is the most effective method to remove solid contaminants. ECI strongly recommends that engines without spin-on filters be retrofitted with an ECI oil filter adapter. It is important to match the size of the filter cartridge (long or short) with the output capacity of the oil pump on the engine.

Of course, the oil filter should be changed every time the oil is changed.

# Oil Content Reports

(Courtesy of RAM Aircraft, LP, Waco, TX)

## Should I use oil content reports?

RAM reminds aircraft operators that one report, especially one deviation from normal report, is not necessarily sufficient reason to become alarmed. There are a number of considerations associated with taking an oil sample as well as preparing the report; plus, there are a number of mechanical considerations associated with estimating engine reliability.

## Background

Certain parts of both Continental (TCM) and Lycoming engines, such as rocker shafts and piston rings, typically wear and deposit small quantities of normal wear particles in the oil. It is a function of engine design.

## The Oil Content Report Sample

The quality of the oil sample has a great deal to do with the report. The individual taking the oil sample should use caution not to take the first oil out of the drain, because the majority of the wear metals could have settled to the bottom of the oil pan. Such a procedure could result in an erroneous reading of the metal concentration. In addition, oil samples should only be taken from hot oil. Preferred engine warm-up should be done slowly, beginning at idle RPM for a brief period limiting idle to 1200 RPM. If a dip tube is used, it must not make contact with the bottom of the oil pan where concentrations of wear metals are likely to be exaggerated. RAM recommends engine pre-heat when the OAT is below 20°F.

## How much is too much?

What is considered a high concentration of wear metal particles? Remember, an oil content report is measured in parts per million (ppm). Imagine a truck filled with 1,000,000 baseballs. If 20 of them have a flaw it is listed as 20 ppm. Many engines have remained in service through TBO, even though they had one or more abnormal metal particle reports.

## Recently overhauled engines

Recently overhauled engines may have higher than normal metal particle reports; however, most laboratories are aware of these situations and usually make appropriate adjustments to their reports when so advised of the recent overhaul.

## Break-in Record

Name \_\_\_\_\_

Street \_\_\_\_\_

City/State/Country \_\_\_\_\_

Zip \_\_\_\_\_ Phone \_\_\_\_\_

A/C Model \_\_\_\_\_

Engine Model \_\_\_\_\_

Airport \_\_\_\_\_

Power Settings \_\_\_\_\_

Airport Elevation \_\_\_\_\_

Tach \_\_\_\_\_ M.P. \_\_\_\_\_

Ground Time \_\_\_\_\_

Flight Time \_\_\_\_\_

Average Hours Flown Per Month \_\_\_\_\_

### Break-in Check List for First Flight

- Read entire contents of this booklet.
- Assure that engine was successfully run-in (if not, refer to section entitled, "Critical Precautions for New and Overhauled Engines.")
- Do not use synthetic oil
- Check oil/fuel levels.
- Pre-lube engine prior to starting.
- Start engine, run up normally, taxi, and take off.
- Do not cycle (feather) propeller during flight.
- Climb out at a low angle of attack. This will prevent cylinder heads from overheating.
- Level off at 2 to 3 thousand feet above ground level.
- Keep power at top of the green arc on the tachometer and manifold pressure gauge or 74% power (whichever is higher) for ½ hour.

# ECi<sup>®</sup> Technical Reference Materials

## Class Reference Manual (Booklet #M108)

Cross-referencing sections include: Lycoming & Continental Engine Models to ECi Cylinder Stud Assembly Class Number to LYC/TCM Cylinder, Piston, Ring, Valve, Guide, Seat, etc. Reference • Radial Engine Manufacturers & Model to ECi Cylinder Stud Assembly Class Numbers • Cylinder Stud Assembly Class Number Differentiations • Continental Cylinder Class Differences • Lycoming Core P/N in Ascending Order to ECi Cylinder Class Number • Continental Core P/N in Ascending Order to ECi Cylinder Class Number.

## Cross Reference Parts List (Booklet #M157)

ECi Part Numbers to Lycoming, TCM & SAP  
ECi Part Numbers to PMA Supplement number

## Engine Trouble Shooting Guide (Booklet #M125)

### Shortcuts to Costly Engine Diagnostics

Failure of Engine to Start • Low Power and Uneven Running • High Oil Temperature • Excess Oil Consumption • Low Oil Pressure • High Oil Pressure • Improper Engine Acceleration • Failure or Engine to Idle Properly • Failure or Engine to Develop Full Power • Engine Stops • Carburetor Leaks Fuel • Engine "Spits Back" in Carburetor • Engine Misses Intermittently • Causes of Excessive Carbon Deposit • Magneto Fails to Delivery Any Spark • Crankcase Fills with Oil (Dry-sump System) • A "Too-Rich Mixture" may be caused by... • and much more!



## PMA Supplements

### Service Publications

Piston Ring Sets • Instructions for AEL65102 Cylinders • Plasma Faced Piston Rings • Instructions for AEL320 & 360 Crankshafts • ECi Cyl for TCM 470-520-550 • Color Codes on Cylinders • Continuing Airworthiness Data and Installation Eligibility of ECi Crankcases • and many others.

### TITAN<sup>®</sup> Cylinder Assemblies

#### Features & Benefits: What You Should Know (Booklet #M105)

All publications are available on our website, CD's and in printed format. Please contact one of our Territory Managers or contact your local engine shop for your copy today!



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