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PLEASE FIND ATTACHED A BRIEF INFORMATION PACKAGE RELATING TO THE INSTALLATION, OPERATION AND CARE OF YOUR ENGINE.

THE INFORMATION IN THIS PACKAGE IS GENERAL IN NATURE AND IS NOT INTENDED TO REPLACE THE MANUFACTURER'S INSTALLATION, OPERATION OR SERVICE PUBLICATIONS, OR OTHER OFFICIAL PUBLICATIONS.

PLEASE ENSURE THAT ALL PEOPLE INVOLVED IN THE OPERATION AND MAINTENANCE OF THIS ENGINE ARE FAMILIAR WITH THIS INFORMATION PRIOR TO ENGINE OPERATION

IF YOU HAVE ANY QUESTIONS OR WOULD LIKE TO MAKE ANY COMMENTS, PLEASE CONTACT US.

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SECTION 1 – ENGINE INSTALLATION AND PRE-START

Complete the installation of the engine in accordance with the aircraft manufacturer's instructions.

Before fitting the oil cooler, oil cooler hoses, or a remote oil filter kit you must ensure that these items are clean and free of all contamination.

If the new engine is replacing an engine in which any amount of metal contamination was found in the oil filter or suction screen, we strongly recommend that the oil cooler is replaced with a new item. Similarly as the propeller governor shares the engine oil system, if any metal contamination was present in the old engine, we strongly recommend that the propeller governor is overhauled and to have the propeller oil dome is cleaned, prior to being fitted on the new engine to eliminate any possibility of any old contamination damaging the new engine.

We recommend flushing all engine flexible hoses with compressed air or a suitable solvent to remove any possible contaminates prior to fitting.

Please take care that all engine openings and fittings remain covered or capped during installation so that a washer or off-cut of lockwire etc does not accidentally find its way inside the engine.

Prior to starting the engine we recommend that the lower spark plugs are removed and the engine turned over by hand to ensure that any residual inhibiting oil is expelled out of the cylinders

Caution: Before turning the propeller or engaging the starter motor, ensure the magnetos / ignition system is turned off and all obstacles and personnel are clear of the propeller arc.

Check that the engine has been filled with the correct grade and quantity of engine oil. For most engines we recommend Aeroshell straight mineral oil for the first 50 hours of operation.

With the magnetos grounded and the lower spark plugs still removed, use the starter motor to crank the engine until oil pressure shows on the aircraft oil pressure gauge. If oil pressure does not show within 15 – 20 seconds, stop cranking the engine and allow the starter motor to cool for a few minutes before repeating this procedure.

Once you have a show of oil pressure, reinstall and re-torque the lower spark plugs.

Check the engine installation and prepare the engine for the initial start.

SECTION 2 – INITIAL ENGINE OPERATION

We would recommend that an external observer watches the initial engine start from a safe distance so that he can identify any problems or faults that may not be visible from the cockpit.

INITIAL START:- DURATION APPROXIMATELY 1-2 MINUTES

Start the engine in accordance with the aircraft manufacturer's instructions.

Oil pressure should show on the oil pressure gauge within 10 seconds. On some aircraft it may then take another 30 seconds for the oil pressure to be indicating within the normal operating range due to restrictors in the oil pressure line and the length of the line to the pressure gauge. If the oil pressure is not within its normal operating range with 30 seconds of engine start, shut the engine down and find out why.

Once you have normal oil pressure, run the engine at approximately 1000rpm for one minute.

Check the idle RPM is approximately correct, the idle manifold pressure is approximately 12" – 14" Hg, and both magnetos are working. When shutting the engine down, check the idle mixture. As you move the mixture from full rich to lean, you should see the rpm rise by between 20 – 50 rpm for most engines. If you have no rev rise or an excessive rev rise, adjust the idle mixture after the engine has been shut down.

With the engine shut down, re-check the engine installation. Pay particular attention for either fuel or oil leaks. Re-check the engine controls and make sure nothing is rubbing against any part of the exhaust system. Make any necessary adjustments such as idle speed and idle mixture.

While you are checking the engine, the residual engine heat will also slightly warm the engine oil.

SECOND START:- DURATION APPROXIMATELY 2 – 5 MINUTES.

Start the engine in accordance with the aircraft manufacturer's instructions.

Aim for a target RPM of approximately 1000 RPM. Allow the engine temperature to warm up until the oil temperature needle is off the bottom peg, around 100°F.

Do a normal but brief run-up checking the magnetos and cycle the propeller.

SECTION 2 – INITIAL ENGINE OPERATION

If you are performing the initial engine start on a Continental engine in a single engine aircraft it is very important that the propeller is cycled so that lubricating oil is supplied to the propeller governor transfer collar. Generally to cycle the propeller increase the RPM to 1600 - 1700 RPM and slowly manipulate the pitch control until you see the RPM decrease by 50 – 100 rpm. If the propeller will not cycle stop the engine immediately and find out why.

With the throttle pulled back, re-check that the idle speed is correctly set. (Idle RPM should be set to the aircraft manufacturer's figures) Slowly pull the mixture out to shut the engine down. If the idle mixture is correct you should see a 25 -50 RPM rev rise. If you have no rev rise it indicates the idle mixture is too lean, if the rev rise is greater than 50RPM the idle mixture is too rich.
With the engine shut down, and the magnetos / ignition system turned off again check the engine and engine installation.

Prior to performing any high power ground runs, cowl the engine, or install a cooling shroud.

Third Start

Start the engine in accordance with the aircraft manufacturer's instructions. If the engine had cooled down after the second start, allow the engine to warm up and then perform a normal engine run up in accordance with the aircraft / engine manufacturer's instructions.

Pay particular attention to the ensure the cylinder head and oil temperatures stay within the normal green operating range during these ground runs.

Particular care should be taken with aircraft that do not have, or have only a single channel cylinder head temperature gauge to ensure that all cylinders are remaining below the specified operating limits during ground runs.

Due to the variation between the engine test stand conditions and the engine installation in the aircraft, all engine operating parameters such as idle speed and mixture, oil pressure, fuel flows and pressures, and manifold pressures must be checked and if necessary adjusted at this time.

Follow the aircraft manufacturer's instructions to check and adjust these parameters to within the specified limits.

SECTION 2 – INITIAL ENGINE OPERATION

Fuel system adjustments are particularly important. Please ensure the idle mixture and speed and the full power fuel flows and pressures are set as specified. It is very important that the take-off fuel flow is not less than the engine manufacturer's minimum fuel flow for your engine model.

Try to avoid any un-necessary ground running or prolonged idling of the engine as this can cause the glazing of the cylinder bores, ring blow-by and excessive oil consumption.

Please refer to the next section, **ENGINE BREAK-IN INFORMATION**, for a more detailed explanation of engine break-in procedures.

After the successful completion of the required engine ground runs, make the aircraft ready for its first flight.

FIRST FLIGHT

Start the engine and perform all normal pre-flight inspections in accordance with the aircraft manufacturer's instructions.

Plan to conduct the first flight in daylight VFR rules. Do not put yourself under any un-necessary pressure.

Conduct a normal take off. Monitor engine operating parameters. Use cowl flaps and shallow climb angle to keep cylinder head and oil temperatures in their normal operating range.

Fly your aircraft at a suitable altitude. Maintain a cruise power setting of between 65% and 75% for approximately ½ an hour.

On landing, remove the engine cowls and thoroughly inspect the engine and the engine installation.

On the satisfactory completion of the of the engine inspection you can resume normal operation of your aircraft bearing in mind the operating conditions that are need to "break-in" the engine as discussed in the next section.

In addition to the manufacturer's requirements, we also recommend that the engine oil and oil filter is changed and inspected after approximately 5 hours of operation.

This is also a good opportunity to check the engine installation for any problems.

SECTION 3 - ENGINE BREAK-IN INFORMATION

How you operate an overhauled engine, or an engine that has had one or more cylinders replaced, will have a large influence on how quickly and how completely the piston rings will be "broken in". The first 10 hours of operation of an engine that has had new piston rings fitted are the most important to ensure the correct "break-in" of the piston rings.

Typically most engine overhaul shops will have run and tested your engine for 1 to 2 hours in a dedicated test facility to verify that the engine is operating satisfactorily before the engine is installed in the airframe.

The main objectives of the test run are:-

- To verify that the engine is producing its rated horsepower.
- To identify and correct any oil, fuel or air leaks.
- To adjust the initial oil pressure, idle speed and idle mixture settings.
- To verify that the fuel system is correctly calibrated.
- To verify the ignition systems is operating correctly.
- To provide a safe operating environment where the operation of the engine can be monitored, and if necessary, the engine shut down.
- And, lastly, to provide the initial "break-in" of the piston rings.

This initial test run starts to break-in the piston rings but it may well take another 50 hours of engine operation to complete the break-in process.

As it is necessary for some wear to occur between the piston rings and the cylinder bores, the type of engine oil used for the first 10 hours of engine operation is very important. In general, oils that contain friction modifiers or anti-wear additives should not be used while the rings are being broken in.

Most aircraft engine manufacturers require that a straight type mineral based oil is used for the first 25 – 50 hours of operation.

The common straight mineral based oils available in Australia are:- AeroShell 100, or Phillips 66 Type M.

By "break-in" of the piston rings, we are referring to the wear that occurs to both the face of the piston ring and the wall of the cylinder bore to create an effective seal of the piston rings in the cylinder bore.

SECTION 3 - ENGINE BREAK IN (CONTINUED)

When the piston rings have been correctly broken in, they provide a seal that does not allow the combustion gases to escape into the crankcase section of the engine, or allow oil to enter the combustion chamber.

Combustion gases escaping past the piston rings is commonly known as "blow-by". Blow-by can cause:-

- Higher oil temperatures.
- High oil consumption.
- Early oxidation and break down of the engine oil lubricating properties.
- High crankcase pressures which may in turn force oil out of the engine breather.

Understanding what happens during the engine break-in process allows us to comprehend how the engine needs to be operated to ensure reliable break-in of the piston rings.

The following information applies directly to steel cylinder bores, but the same principles with some qualifications also apply to other types of cylinder bores such as channel chrome or Cerminil.

Most compression rings used in aircraft piston engines are a semi-wedge design, with a tapered portion on the ring face that wears against the cylinder wall. Combustion pressures act on the semi-wedge profile of the ring, forcing the tapered face of the ring against the cylinder wall.

A seal is formed between the ring and the cylinder wall when these parts have worn to conform to each other's shape.

For the required amount of wear to occur between the piston rings and the cylinder wall, the piston rings must be expanded against the cylinder wall with sufficient force.

It is the combustion pressures created during the power stroke, that force the piston rings against the cylinder wall. Generally the combustion pressures in the cylinder only become great enough for reliable ring break-in when power settings above 65% are used.

When a cylinder is made or overhauled, the cylinder wall is honed with abrasive stones. The honing process, roughens up the cylinder wall and produces a series of minute peaks and valleys in the surface. It is these peaks and valleys that are commonly referred to as the "cross-hatch" pattern on the cylinder wall.

During the break-in process, these peaks are worn off the cylinder walls by the piston rings.

SECTION 3 - ENGINE BREAK IN (CONTINUED)

One particular problem we want to avoid while breaking in the piston rings is a condition known as "glazing".

When a cylinder is said to be glazed, it means that oxidised oil has been deposited as a varnish layer in the valleys all the way up to the peaks of the hone pattern.

This varnish layer of oxidised oil causes two problems.

Firstly, it stops any further wear and break-in of the piston rings. As a result the rings may not conform completely to the cylinder wall leading to blow-by.

Secondly, the varnish layer is too smooth and can cause the piston rings to hydroplane over oil that is on the cylinder wall. That is, excessive amounts of oil build up in front and under of the ring face. The resulting hydraulic pressure of the oil on the ring face is enough for the ring face to lift off the cylinder wall. This allows oil to pass under the ring and into the combustion chamber resulting in excessive oil consumption and fouled spark plugs.

There are a number of views as to how glazing can occur. The most common view is that when the engine is operated at low power settings, the rings are not pushed hard enough against the cylinder wall, leaving a very thin film of oil between the ring face and the cylinder wall. This oil film is of sufficient thickness that it stops any wear occurring between the face of the piston ring and the cylinder bore. This results in the surfaces of the piston ring and the cylinder bore not fully conforming to each other. In addition to the necessary wear of the surfaces not occurring, the oil film is also oxidised by the high temperatures in the combustion chamber creating the varnish layer and the glaze effect.

Another contributing factor to glazing is also thought to be excessive heat. During operation at very high power settings, if the heat generated from the frictional contact between the piston rings and cylinder wall is allowed to build up, then the high cylinder wall temperatures can oxidise oil that has been squeezed into the valleys of the hone pattern. This oxidised oil builds up as a layer of varnish on the cylinder wall and causes the cylinder bores to become glazed. Keeping the engine cool during high power operation stops glazing occurring by this process.

Once a cylinder becomes glazed the only effective way to correct the problem is to remove the cylinder, re-hone the cylinder bore to remove the glaze, replace the piston rings and start the break-in procedure again.

SECTION 3 - ENGINE BREAK IN (CONTINUED)

In summary, to promote the reliable break-in:-

- Follow the manufacturer's recommendations regarding the type and grade oil to be used for break-in.
- Perform the start, warm-up and pre-flight checks as you would for any other engine, but avoid any prolonged operation at low power settings.
- During break-in try to keep cylinder heads cool and oil temperatures in the normal operating range.
- Use full power for take off and climb, but carefully monitor engine temperatures. Use cowl flaps and generous mixture settings to keep the engine cool.
- Step climb the aircraft and use cowl flaps in cruise if necessary to keep the engine cool.
- In cruise maintain power settings of between 65% and 75%.
- For normally aspirated engines it will be necessary to cruise at lower altitudes to obtain the required cruise power settings. Density altitudes should be kept below 8000 ft.
- Avoid long descents with low manifold pressures.
- Monitor your oil consumption.
- Change the oil and oil filter in accordance with the manufacturer's requirements.

For further information please refer to the latest editions of :

- For **LYCOMING ENGINES** Service Instruction **1014 and SB480**
- For **CONTINENTAL ENGINES** Service Bulletin **SIL99-2**

SECTION 4 - ENGINE BAFFLES

Engine baffles have a critical role in ensuring that the engine is correctly cooled. Engine baffles and cowls are designed to provide an air seal between the top and bottom of the engine. This air seal ensures that the cooling air is correctly directed through the engine, oil cooler and engine compartment to guarantee the proper cooling of the engine.

Just as a leak in the radiator in your car can cause your car engine to overheat, leaks in engine baffles can cause your aircraft engine to overheat.

Poorly fitting or maintained engine baffles can result in the cooling air going around instead of through the engine.

Leaks can cause uneven cooling of the engine. One or more cylinders may be operating at substantially higher temperatures than the other cylinders.

A multi-channel Cylinder Head Temperature gauge is the best way to verify that all cylinders are operating at similar temperatures. For continuous operation the Cylinder Head Temperatures should be kept below 400°F and preferably below 380°F.

High cylinder head temperatures can cause:

- Faster wear rates of top end engine components, in particular exhaust valves and valve guides.
- Cylinder head cracks.
- Oxidised engine oil and glazed cylinder bores.

Things to look for when inspecting and refitting baffles include:-

- Ensure all baffles are correctly fastened to the engine.
- Make sure no baffles are missing. Pay particular attention to small baffles that need to be fitted around oil coolers, engine mounts, inter-cylinder baffles, etc.
- Seal excessive gaps where baffles are attached to the engine with a suitable flexible sealant. Check that large gaps are not left around the inter-cylinder baffles.
- Check the baffle rubbers have not become worn or torn.
- Check that when the cowls are fitted the baffle rubbers form a good seal. (Dust tracks on the inside of the cowl can indicate where leaks are occurring.)
- Check that the cooling air pressure in flight is not folding baffle rubbers back and dislodging them from their correct position.

Keeping your engine baffles in good condition will benefit your engine and save you money in the long run.

SECTION 5 - ENGINE CARE

A few simple tasks performed each time you fly will help to identify potential problems before they become a safety issue and will also help to prolong your engine life.

VISUAL INSPECTION OF THE ENGINE

Conduct a thorough visual inspection of the engine. Check that there are no obviously loose or missing items (magnetos, starters alternators etc may have come loose on the previous flight). Check oil level and check for oil leaks. Check that the engine baffles and baffle rubbers are in place. Check that no lines or hoses have become chaffed. Check that no items are rubbing against the exhaust system.

PULL THE PROPELLER THROUGH

Caution: Ensure that the ignition/magneto switches are in the off position before pulling the propeller through and stand clear of the propeller at all times.

By pulling the propeller through 2 or 3 revolutions you will be able to feel the resistance from the compression stroke of each cylinder. The compression resistance of each cylinder should feel even. If you feel less resistance it indicates that a cylinder may have a compression leak past the exhaust or inlet valve or past the cylinder rings. If you do find a "soft cylinder" have it investigated and repaired. Operating an engine with cylinder compression leaks can lead to more serious problems such as burnt exhaust valves, holed pistons, and in some cases complete engine failure. Another advantage of pulling the propeller through is that is helps to spread a lubricating film of oil over internal engine surfaces prior to starting.

ENGINE START

Start the engine and check the oil pressure is in its normal range. Keep RPM (and load on the engine) to a minimum while the engine warms up. High RPMs before the engine has had the opportunity to warm up can lead to the premature wear of internal parts due to lack of lubrication. Many of the internal engine parts are splash lubricated, most notably the camshaft lobes/tappet body faces in Lycoming engines. Sufficient time should be allowed for the splash lubricated parts to receive a good coating of oil and for the oil to warm up before increasing power above 1500 rpm. A second reason to properly warm up the engine is that until the engine reaches its minimum operating temperature, some of the important internal clearances may be outside the desired operating range. As a part gets hotter it expands. Operating the engine at high power settings before the engine has had the chance to warm up may lead to premature wear due to incorrect clearances.

SECTION 5 - ENGINE CARE (CONTINUED)

Aggressive leaning on the ground at idle can help to avoid fouled spark plugs. If you do lean the mixture while idling and taxiing, lean it so much that if you open the throttle the engine will cut out. This helps to prevent the engine from being operated partially leaned at higher power settings. Remember unless you are at a very high density altitude most takeoffs should be performed at full throttle and full rich mixture setting.

RECORD ENGINE OPERATING PARAMETERS (DATA LOGGING)

Keeping a simple log of important engine operating parameters can be very useful in determining if any changes are occurring to your engine over time. Logging engine parameters enables you to identify trends. For example, if idle oil pressure has consistently been around 45PSI at 700RPM with an oil temperature of 185°F and you then notice it slowing dropping to 35PSI, it is a good indication that something has changed within the engine.

Good information allows you and your maintenance personnel to identify potential problems before they seriously affect the engine operation, cost you a lot of money, or create a safety concern.

To obtain consistent information, try to record the parameters under the same operating conditions. For example, in most engines oil pressure changes with oil temperature and engine RPM. Therefore to obtain consistent oil pressure readings, always try to log the oil pressure at a given RPM and temperature.

An example of a simple manual Engine Condition Log is shown at the end of this section.

AVOID RAPID CHANGES TO POWER SETTINGS WHERE POSSIBLE

Where possible smoothly increase or decease the engine power.

Try to avoid rapid changes to power settings and engine RPM.

When cycling the propeller, do so slowly. On engines equipped with counterweights, rapid RPM changes can cause premature wear of the counterweight bushes and pins and the subsequent detuning of the counterweight system. Detuned counterweights no longer absorb the vibrational energy at the desired frequency. When not absorbed, this vibrational energy can cause many maintenance problems from cracked engine baffles and propeller spinners to broken crankshafts. On sandcast Continental IO-520 series engines, an alternator belt that keeps coming off is a sign that the counterweights have become detuned.

SECTION 5 - ENGINE CARE (CONTINUED)

ALLOW THE ENGINE TO COOL DOWN BEFORE SHUT DOWN

Use your engine monitor as a guide to see when your engine is cool enough to shut down.

For many aircraft, the coolest your engine will be is at the end of your landing rollout, especially after a long descent. Taxiing to the parking area or your hanger may actually warm the engine up.

The above statement applies to both naturally aspirated and turbocharged engines.

Use your common sense, if the CHT are near 300°F, and the oil temperature is 170°F-180°F your engine is cool enough to shut down.

If you are sitting there with the engine idling (aggressively leaned) and after after a minute or two, the CHT's and oil temperature is not decreasing at any appreciable rate, a longer period of idling the engine is not going to make the engine any cooler.

The one occasion when you many need to idle the engine for longer periods to allow the engine to cool before shutting the engine down, is after you have been out to the run-up bay and conducted a high power engine ground run. This is the one time where you may need to idle the engine for a few minutes to allow the engine to cool down, before you shut it down.

SECTION 5 - ENGINE CARE (CONTINUED)

ENGINE OIL FILTERS

We also highly recommend that all engines are fitted with a full flow, paper element type oil filter. Many engines, especially older engines were made with only an oil screen. The old oil screens are generally only a fine wire mesh that will catch rocks and other large bits of debris, but essentially do nothing to filter smaller particles out of the engine oil.

Full flow paper element type oil filters are much better for the following reasons:-

- Vastly improved oil filtration over an oil screen.
- Much better protection, and less wear of critical engine components due to the superior oil filtration.
- Improved detection of potential problems, from the ability of the filter element to hold contaminates which can then be identified when the filter element is inspected.

If your engine is not fitted with a full flow oil filter, and the engine oil system becomes contaminated for any reason, a full strip of the engine will be required to check the condition of the main and connecting bearings and other internal engine parts.

If a full flow oil filter is fitted, in some instances, the source of the engine oil contamination can be corrected and the engine returned to service without the need for the engine to be stripped.

STC's are now available for nearly all engine and aircraft types to fit full flow paper element type oil filters.

If a full flow oil filter kit is available for your engine, and you elect not to have one fitted, there may also be warranty implications to be considered.

PISTON ENGINE CONDITION LOG

AIRCRAFT REG ______________ ENGINE MODEL _________________ SERIAL NO _______________________________

		AT IDLE			AT CRUISE							
		OIL PRESSURE			OIL PRESSURE							
DATE	HOURS	PSI	RPM	TEMP	PSI	RPM	TEMP	CHT	EGT	OIL ADDED	FUEL USED	COMMENTS

SECTION 6 - ENGINE DATA MONITORS AND DATA LOGGING

Advances in electronics have revolutionised the ability to monitor, display, log and provide alarm functions for engine operating parameters.

A number of manufacturers now provide a range of systems that can be fitted to nearly any aircraft.

The original engine instruments supplied when most aircraft were constructed in the 1960s and 1970s are, by today's standards, very basic. Simple aircraft were equipped with a tachometer, oil pressure gauge and oil temperature gauge, while more sophisticated aircraft may have also had a manifold pressure gauge, single channel cylinder head temperature gauge, an exhaust gas or turbine inlet temperature gauge and a pressure based fuel flow gauge.

In many aircraft, some of these instruments were located in positions well away from the central area of the pilot's vision. Of even more concern, very few of these instruments had any alarm functions. Only a limited number of aircraft were ever fitted with a low oil pressure-warning light.

In some instances these original instruments can produce incorrect readings or misleading information. For example, the pressure based fuel flow indicators indicate a high fuel flow if a fuel injector nozzle becomes blocked. A single channel cylinder head temperature gauge, or EGT, may indicate that the cylinder to which the CHT or EGT is fitted to may be operating within specified limits, but this reading from one cylinder does not mean that all cylinders are within the specified operating limits.

Fortunately, the new engine monitoring systems overcome many of these limitations.

Typically, engine monitors have the ability to accurately monitor, display, log and alarm all engine operating parameters which include: -

- Individual cylinder head and exhaust gas temperatures
- Turbine inlet temperatures on turbocharged engines
- RPM
- Manifold pressure
- Fuel Flow (Normally derived from a turbine type flow meter)
- Oil Temperature
- Oil Pressure
- Voltage
- Outside Air Temperature

SECTION 6 - ENGINE DATA MONITORS AND DATA LOGGING (CONTINUED)

The data logging functions of the engine monitors allow all of these parameters to be recorded. Depending on the amount of memory and the configuration of a particular system, engine operating parameters can typically be logged at 6 second intervals for 100 hours of operation This data can be down loaded to other computers, and the complete operating history of the engine graphically displayed and analysed. This feature makes it easy to identify trends, or faults that might have occurred.

In addition to the pilot periodically scanning the engine instruments to detect potential problems, engine monitors also continuously scan the engine operating parameters. Should the engine monitor find any parameter be outside of prescribed limits, it will raise an alarm to draw the pilot's attention. Typically, alarm conditions are identified by the relevant display changing to red and flashing. This mode of displaying an alarm condition is far easier for the pilot to identify than looking for a needle that is no longer in the green arc. Some engine monitors also include audible alarms that can be linked through the audio panel. For example, if the oil pressure was low, a synthetic voice repeats "oil pressure, oil pressure" in the pilot's headset.

Other benefits of engine monitoring systems include:

- Improved management of fuel mixture settings and consequent fuel savings. In some aircraft the fuel savings alone will offset the cost of installing an engine monitor in 300 - 500 hours of operation.
- Alarm functions for low oil pressure or high oil temperature.
- Alarm function for high Cylinder Head temperatures.
- Reduced maintenance cost by promoting better engine operation.
- Providing accurate data to identify the cause of a fault, and to confirm that a fault has been fixed, again reducing maintenance costs.
- The ability to identifying particularly damaging engine conditions such as pre-ignition in an individual cylinder. With an engine monitor a pilot will be alerted to a pre-ignition event by a very high and rapidly increasing cylinder head temperature and the pilot can then take suitable corrective action to save the engine.

However, the biggest benefit from fitting an engine monitoring system is the added safety that such a system offers. The safety benefit of engine monitoring systems is that accurate information for the whole engine is displayed to the pilot. In addition the engine operating parameters can be collected and trend analysed.

A review of the operating parameters over time will help to identify if any problems are starting to develop within the engine. Appropriate maintenance can then be planned to rectify these potential problems before they become a safety issue.

SECTION 6 - ENGINE DATA MONITORS AND DATA LOGGING (CONTINUED)

Should an engine fault develop in flight, the engine monitoring system provides an early warning to the pilot that the fault is developing or has occurred. If you are ever in the unfortunate situation of having a partially blocked fuel injector nozzle causing a detonation or pre-ignition event, only a multi channel engine monitor will provide timely and accurate information to the pilot so that corrective action can be taken before the engine is damaged. A few extra minutes warning of an engine fault may make all the difference between a successful landing at the nearest airfield and having the engine seize over hostile terrain while trying to reach the airfield.

Engine monitors provide the data so that operators and maintenance personnel can have a high level of confidence that the engine is operating as it should, and warnings when it is not.

SECTION 7 – SOME MORE THOUGHTS ON ENGINE DATA MONITORS DETONATION AND PRE-IGNITION

Putting aside the debate about what is the most appropriate fuel mixture setting, and engine operation lean-of-peak, having a modern multi-channel engine monitor fitted enhances the safety of your aircraft.

By today's standards a single channel EGT or CHT gauge is manifestly inadequate to indicate the current operating condition of air cooled piston aircraft engines. This is particularly so with higher horsepower and more complex general aviation piston engines.

Only a multi-channel engine monitor that has a CHT and EGT for each cylinder provides the pilot with sufficient information to show that the engine is operating correctly and safely.

Engine monitors with data logging allow the pilot and maintenance personnel to detect potential engine operating problems before they become safety issues. An engine monitor will identify problems such as:-

- defective spark plugs.
- partial blockage of a fuel injector nozzle.
- cylinder cooling problems.
- EGT's can be used to check that the magneto timing is correct.
- Using the change of each individual EGT when a magneto check is performed to confirm that the ignition system is working correctly.
- detecting exhaust valve leakage and seating problems.
- exhaust gas leaks. (e.g. cracked exhaust pipes)
- providing hard data to maintenance personnel when there is an engine problem, and also confirming data that an engine problem has actually been fixed.

And importantly

- detonation and pre-ignition which can cause catastrophic engines damage if not detected.

A simple defect such as a faulty spark plug can cause detonation which in turn can lead to pre-ignition even at "normal" mixture settings.

Without adequate instrumentation, a single spark plug costing $40.00 could be the critical linking factor that leads to the destruction of a $80,000.00 aircraft engine, or worse still, being the cause of a serious aircraft accident.

Consider for a moment, the normal variations that occur in manufacturing and in operation. In service, a spark plug typically experinces around 20 high temperature, and high pressure combustion events per second. Over time this can cause individual spark plugs to operate at a higher temperature than normal for a particular spark plug specification.

SECTION 7 – SOME MORE THOUGHTS ON ENGINE DATA MONITORS DETONATION AND PRE-IGNITION

Given the right (or wrong depending on how you look at it) combination of circumstances such as high ambient temperatures, high cylinder head temperatures, and a mixture that is either not rich enough or not lean enough, in conjunction with this single spark plug that is operating hotter than its normal heat range could be the critical factor that causes pre-ignition in a cylinder.

While it is not possible for an engineer or pilot to identify the 1 in 10,000 1 in 20,000 spark plug that is operating outside of its specified temperature range by its appearance, a modern multi-channel engine monitor will rapidly detect the consequences of pre-ignition (very high cylinder head temperature and low exhaust gas temperature) and provide alarms to the pilot for corrective action to be taken (richen the mixture or reduce power if possible) to stop the pre-ignition event.)

If the pre-ignition is not identified, catastrophic damage can occur to the piston / cylinder / engine within 30 to 60 seconds.

A single cylinder CHT and EGT is clearly inadequate to reliably detect and avoid detonation and pre-ignition.

This one, of many, possible malfunctions scenarios, clearly highlights the safety benefit that modern engine monitors provide.

SECTION 8 - LOSS OF OIL PRESSURE IS AN *EMERGENCY*

As we specialise in the repair and overhaul of aircraft piston engines, we unfortunately see some of the more dramatic engine failures.

Over the years, one of the most common causes of catastrophic engine failure that we have seen is loss of the engine oil, and the subsequent loss of engine oil pressure.

When we examine the circumstances of these engine failures, a common scenario that we hear from the pilot, is that they noticed a drop or reduction of the engine oil pressure, but as the engine seemed to be operating normally, they continued flying, not recognising the seriousness of their situation.

In some instances, the pilot thought that all that had happened was the oil pressure gauge had stopped working. This could be a fatal mistake.

Most of the oil starvation engine events that we have seen are caused by the loss of the oil from the engine. It is the low oil level that then causes the low oil pressure. Sometimes as the quantity of oil remaining in the sump gets very low, you might see a slight increase in oil temperature.

The quantity of oil in the engine is not monitored during flight. The first indication of a low level problem is normally a reduction in oil pressure, as indicated by the oil pressure gauge.

A typical scenario leading to an oil starvation event is as follows:-

Some problem causes an oil leak from the engine. The oil leak may be relatively slow, such a leak from a part of the engine where the oil is not under pressure, such as a leak from pushrod tube, or a rocker cover gasket, or the oil can leak at a much faster rate from a part of the engine where oil is supplied under pressure i.e. from a ruptured oil hose, or from a failed oil filter seal or similar.

Regardless of the cause of the oil leak, once the engine has lost enough oil, the oil level in the sump falls below a critical level. Without sufficient oil in the engine, engine failure may be imminent unless the loss of oil, and loss of oil pressure is recognised by the pilot, and appropriate action taken.

If the amount of oil in the engine sump drops below a safe level, the pickup for the oil pump will not be submerged in oil, and air instead of oil will be drawn into the oil pump. Once air instead of oil is being sucked into the oil pump, critical parts of the engine, including the engine bearings, will no longer receive the vital oil lubrication that they require to operate.

SECTION 8 - LOSS OF OIL PRESSURE IS AN *EMERGENCY*

If air is sucked into the engine oil pump, the supply of pressurised oil to engine bearings and other internal components becomes aerated and the engine oil pressure indication will fluctuate and drop .

This is a key warning sign. Pilots need to know that any appreciable fluctuation or reduction of oil pressure on the oil pressure gauge is cause for immediate action.

Depending on the design of the engine, and in particular the design of the sump and oil pick-up, it may only need a very small further loss of oil from the engine until the oil pump is mainly drawing air and very little oil. Once this happens the indicated oil pressure drops to near zero and if the engine continues to be operated, failure is imminent.

Initially, while the engine oil pressure is low or fluctuating, the engine may appear to be operating normally. This may lead the pilot to think that there is an error with the oil pressure gauge or sensor, and that the engine will continue to operate relatively normally.

This can be a fatal error of judgement on the pilot's part.

What is really happening within the engine, is that critical engine parts, such as, the main and connecting rod bearings, are no longer receiving the vital lubrication that they require.

As the oil pressure continues to fall, the amount of lubricating oil supplied to the bearings becomes less and less.

With low or no oil pressure, the flow of oil to main and connecting bearings and other critical engine parts essentially stops.

The main and connecting bearings only have the residual oil between the bearing shell and crankshaft journal to provide lubrication. But with no oil flow, this residual oil quickly heats up, and loses viscosity. That is, the oil becomes thinner, and shortly the thin oil film between the bearing and the journal can no long withstand the applied loads.

When the oil film can no longer withstand the applied load, metal to metal contact occurs between the bearing and crankshaft journal. Once this happens, the situation runs out of control very quickly.

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The friction and forces from the metal to metal contact of the bearing and crankshaft journal results in the rapid and complete destruction of the bearing shell. This is accompanied by a rapid temperature increase of the crankshaft bearing journal and surround areas such as connecting rod big end.

The crankshaft, connecting rods and connecting rod bolts are all made from steel. In common with all metals, beyond a certain temperature, the strength of steel decreases as the temperature increases. In a short time the bearing journal, and/or the connecting rod big end is red hot, and the steel is significantly weakened and easily deformed. (Think of how a blacksmith works steel)

Once the steel is red hot and weakened, either the crankshaft, connecting rod, or connecting rod bolts are no longer able to withstand the applied loads and something breaks. Normally it is either the connecting rod bolts or the connecting rod itself that break under such adverse conditions.

Just depending on what breaks first, the engine may just stop, or the engine may continue to operate in a seriously compromised state for a short period before something else breaks.

The metal contamination form the destroyed bearings, and the flailing of broken connecting rods within the engine causes enormous internal engine damage. Not much can be savaged from an engine that has failed in this manner.

At cruise power settings, I would suggest that the typical time frame between when the first fluctuation or reduction of oil pressure occurs (caused by the aeration of the oil) until the catastrophic engine failure occurs is somewhere in the range of 1 - 10 minutes.

So, what should you do, if you see any abnormal fluctuation or reduction of oil pressure.

1. If you are in a single engine aircraft you need to make a forced landing **as soon as you can**. If you try to press on to reach the next runway/airfield/airport you run the risk of a catastrophic engine failure before you reach the next runway/airfield/airport.

SECTION 8 - LOSS OF OIL PRESSURE IS AN *EMERGENCY*

2. If you are in a twin engine aircraft you need to land at the nearest available suitable runway/airfield/airport. Be prepared for single engine operation as the propellers on most twin engine aircraft will automatically feather when oil pressure is lost, in which case the engine can not deliver any useful power or thrust.

In either case, to prolong the operation of the engine, **reduce power.**

If you are in a situation where the power can be reduced, do so. With low oil pressure, the engine will operate for a much longer period at idle power than it would at cruise power.

You want to try to avoid catastrophic failure of the engine because once the catastrophic failure has occurred you do not have any more options.

If the engine is operated at a low power setting, the engine may retain enough integrity to operate for a brief period at a higher power setting to give you the opportunity to avoid an obstacle while trying to land or select a better forced landing area.

After landing, you will need to have the engine inspected to determine the cause of the engine oil loss, and low engine oil pressure.

If it is found that the engine has been operated with oil below the minimum safe level, and/or low oil pressure, the engine will need to be stripped and thoroughly inspected before it can be returned to service.

Do not be tempted to correct the oil leak, re-fill the engine with oil and continue operation. Damage to the bearings may have occurred that is not immediately apparent.

When an engine has been operated with no oil pressure, the oil filter can be clear of metal contamination, but the bearings may have been damaged. (If you have no oil flow, the damage from a bearing can not be flushed out of the bearing, into the sump, picked up by the oil pump, and then caught in the oil filter.)

If the bearings have been damaged, the engine could fail on the next flight, or in twenty flights time. Unless the engine is stripped and inspected you can not be confident that no damage has been done to the engine.

SECTION 9 - OIL ANALYSIS

Oil analysis is a tool that can be used by the owner and maintenance personnel to make more informed decisions as to the current condition of an engine.

The parts used in aircraft engines are made from a number of different metals and alloys (pistons are made from an aluminium alloy, cylinder barrels are generally steel, piston rings have a chrome face, main bearings are made from an alloy of copper, tin and lead, connecting rod bushes are bronze etc). In operation all these parts wear slightly, depositing minute particles of the metal in the oil.

Oil Analysis programs generally test for nine different substances: copper, iron, chromium, lead, tin, aluminium, silicon, molybdenum and sodium. The wear metal particle concentrations are usually expressed in parts per million (PPM)

If wear of a particular part accelerates then the concentration of wear metal particles increases, signalling a problem.

Analysis of the various levels of the individual wear metals assists in identifying the part that is wearing at the accelerated rate.

Oil analysis assists in detecting problems early so minor problems can be repaired before more expensive repairs are required or a major failure occurs. For example high levels of silicon in the oil can indicate that dirt is entering the engine. Fixing the air cleaner is cheaper and easier that having to overhaul the cylinders after the dirt has caused wear to the piston, rings and cylinder barrel.

The major advantage of oil analysis is confidence. As long as the level of the various wear metal elements is fairly consistent over time and do not show a sharp rise, the operator can be reasonably confident that the engine was operating normally when the oil sample was taken.

LIMITATIONS

Oil analysis provides a good guide as to the wear that is occurring in an engine but it does have limitations. For example as oil analysis is based on examining the concentrations or various substances in the used engine oil, it will not predict the sudden breakage or fracture of a part.

Some caution is also required when comparisons between different oil samples are made. Changes to the type of use, sampling procedures and seasonal changes can all result in variations to the wear levels in the oil sample.

SECTION 10 - WARRANTY INFORMATION

The relevant warranty section from our TERMS AND CONDITIONS FOR THE SALE OF PARTS AND SERVICES BY RIVERINA AIR MOTIVE PTY LTD has been reproduced below for your information.

9.1 Riverina warrants that the Services will be performed with due skill and care.
9.2 In relation to Parts supplied by Riverina to which a manufacturer's warranty applies, Riverina will procure the benefit of that warranty for the customer, which is the sole and exclusive warranty for those goods.
9.3 In relation to Parts supplied by Riverina to which a manufacturer's warranty does not apply, Riverina warrants that the Parts will be of acceptable quality.
9.4 In relation to Parts supplied by Riverina, that Riverina purchased from overseas suppliers to service the Customer's Equipment, the Customer agrees Riverina is acting as the Customer's agent, and will not be deemed to be the Manufacturer for warranty purposes as may be interpreted under the Australian Consumer Law.
9.5 In relation to second hand parts Parts supplied by Riverina, second hand parts are sold on "as is where is" basis with all existing or future inadequacies, faults or defects, if any, whether know or unknown. Riverina does not warrant used or second hand goods that they are fit for purpose or free from defects.
9.6 The Customer is responsible for the cost of all transport charges in respect to the return any Parts and or Equipment which are the subject of any claim pursuant to this clause 9 and the supply by Riverina of any replacement Parts.
9.7 These warranties are in addition to other rights and remedies that are available to the Customer at law. The Services and Parts supplied by Riverina come with guarantees and/or warranties that can not be excluded under the Australian Consumer Law.
9.8 Warranty Claim Procedure. You must apply to Riverina in writing within 14 days of appearance of the defect with adequate proof of the date that Parts were supplied or the Equipment was Serviced by Riverina, the number of operational hours of the Parts or Equipment since supply, and the date and circumstances of the event that may give rise to a warranty claim.
In relation to Parts that were supplied to which a manufacturer's warranty applies, the warranty period is the time stipulated by the manufacturer. In relation to Services performed by Riverina, the warranty on Services is within 12 months from when the Equipment was first used, but no longer than 24 months from the date of the completion of the Services, provided the Customer takes all necessary measures to ensure that the Equipment is adequately stored and protected.

SECTION 10 - WARRANTY INFORMATION

9.9 Upon becoming aware of any problem, you or any other person operating the Equipment must take all necessary steps to minimise any damage that may arise. This warranty shall not apply to Equipment or Parts that have been subject to misuse, neglect, deterioration, foreign object damage, tampering, improper storage, fuel contamination, detonation, pre-ignition, accident or operated beyond manufacturer's limits such as, but not limited to, speed, temperature or manifold pressure.

To assist you in understanding your obligations with regard to the operation of your engine or component, and to ensure you do not inadvertently compromise any warranty coverage that you are entitled to, below is a discussion about some aspects of the operation of your engine and warranty provisions for your consideration.

NORMAL SERVICE REQUIREMENTS

It is a condition of your warranty that your engine is maintained in an airworthy, mechanically sound condition and serviced regularly in accordance with the engine manufacturer's recommendations and standard practices.

In particular we would like to emphasis that while your engine or components may have been operated, or bench tested prior to delivery, further adjustment may be required when the engine or component is installed.

Fuel system adjustments are particularly important. Please ensure the idle speed and mixture is correctly set, and that full power fuel flow is correctly adjusted and set as specified by the engine / aircraft manufacturer. For some engines this may require flying the aircraft, observing the fuel flows, making adjustments, and then re-checking the fuel flows.

Any defect or fault or any parts identified as needing repair or replacement or which are identified as a potential problem must be rectified as soon as physically possible.

Upon becoming aware of the development of any problem, you, or any other person operating the engine must take all necessary steps to minimise any damage that might arise.

SECTION 10 - WARRANTY INFORMATION

Generally Warranty does not cover:

- any service or maintenance items, adjustments or any expendable items as specified under the heading Maintenance items.
- any problem caused by the use of incorrect types & grades of fuel, oil or lubricants.
- any problem caused by the failure to maintain proper levels of fluids, lubricants, fuels, or contamination of fluids.
- any problem caused by detonation or pre-ignition caused by operator mishandling.
- failure arising from normal wear and tear and the gradual reduction of in operating performance of the engine or component.
- diagnostic costs unless accepted as part of an authorised claim.
- components which have not failed and which are replaced during routine servicing or maintenance.
- engines that have not been maintained in accordance with the service requirements.
- any repairs required as a result of continued operation of the engine once a defect or fault has been identified.
- the costs incurred in improving or reconditioning the engine or components to a condition superior to that at time of defect or fault occurring.
- any problems caused by misuse, neglect, abuse or improper servicing, dust, chemicals, fire, illegal use, malicious damage, impact, accident or corrosion.
- any subsistence charges such as accommodation, and food.
- any cost associated with travelling expenses for either you, or for maintenance personnel.
- any consequential loss or damage of any kind.

SECTION 10 - WARRANTY INFORMATION

Maintenance Items

The service, maintenance & expendable items that are not covered by Warranty include:

- All Routine engine maintenance and adjustments.
- All air filters, oil filters, spark plugs, and similar consumable items.
- The cleaning of fuel nozzles and flushing of fuel lines.
- Consumables such as oils and lubricants unless required as a direct result of the failure of covered component.
- Stripped threads and fastening devices.

If you are unfortunate and need to make a warranty claim, please contact us before you commence or authorise any repairs.

As I hope you understand, if we a making a warranty claim on your behalf to a manufacturer, we have procedures that we are required to follow, and approvals to obtain before any repairs can the authorised.

If you proceed with any repairs before the manufacturer has authorised any repairs to be performed, you may have to pay the costs of the repairs that you authorised.

One area that can be contentious, is who pays the costs, for additional work that maybe required, that is not the direct warranty repair required.

For example, the time required to remove and refit engine cowls may take a few minutes on one aircraft, and a few hours on another aircraft. Similarly with some aircraft, cylinders and engine accessories are readily accessible, while in other aircraft, it may be necessary to remove the entire engine to gain access to the required part of the engine or engine accessory. Some aircraft are relatively well designed from the perspective of performing maintenance, while others, are very difficult and time consuming.

Due to the wide range of circumstances and possible scenarios, it is not possible to provide a universal answer to this question of who pays for any additional costs that may not be covered by the manufacturer's warranty.

In the event of a warranty claim, this is generally an issue that has to be addressed on a case by case basis.

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POSTAL ADDRESS
P.O. BOX 170
SALISBURY SOUTH
SA 5106
AUSTRALIA
ABN 76 008 197 79

WARRANTY CLAIM FORM

This form is to be completed prior to presentation of the engine for repairs. Please note, that we will not accept costs or responsibility for repairs performed by others, unless previously authorised by us.

Customer Name:____

Address: ____

Telephone No: ____________________ ______ **Mobile:** ______________________________

Email: ____

ENGINE DETAILS

Date of Installation: / / **Riverina Job No.** ____________________

Engine Model: __________________________ **Engine S/N:** _________________________

Aircraft Registration: ____________________ **Aircraft Model:** ______________________

CLAIM DETAILS

Date of Fault: / /

Hours of Operation since Overhaul (TSO): ______________ **Hours**

Description of Problem:

____

____

Did you have any warning or indications of the problem? ______________________

____

Name and Contact Information of the nearest / your preferred Maintenance Organisation

Name: ____

Address:____

Contact : __________________________ **Phone :**___________________________________

Signed : ____________________ **Name :** __________________**Date :** / /