RAVEN INVERTED OIL SYSTEM

Installation Instructions

These updated instructions supercede all other versions or varients

Why install the Raven Inverted Oil System?

Oil pressure is critical to aircraft engine operation and longevity! An aircraft engine draws its oil supply from a sump via an oil pump and pick-up tube. Oil must be available at the oil pump pick-up tube at all times. If at any time there is no oil available at the oil pick-up tube there will be immediate loss of oil pressure and no oil will be circulated through the engine. The engine's original design does not pose problems as long as the aircraft maintains normal, level flight. However, aerobatics and inverted flight do pose problems.

Regardless of whether your engine is equipped with a horizontal or vertical pickup tube the operational principals are the same – during normal flight, oil is picked up by the pump via a pick-up tube from the bottom of the sump. However, during inverted flight, the sump is upside-down and the oil is now in the top of the crankcase instead of the bottom of the sump where the pick-up tube is located, leaving no oil available to the pickup tube and resulting in loss of oil pressure. To make matters worse, substantial loss of oil occurs as the oil now flows freely out of the breather line at the top of the crankcase.

Installation of the Raven inverted Oil System works to block the oil flowing from the breather tube during inverted flight, oil is then picked up at a point at the rear of the engine ca
back to the oil pump to keep the engine supplied with oil, thus maintaining critical oil pressure and eliminating oil loss.

This kit is designed for Lycoming aircraft engines, and becomes an extension of the engine's existing lubrication system. The gravity-operated valves require no electrical connection, and operates in both inverted and negative-g flight maintaining proper engine lubrication without time restriction. The Raven system has three basic configurations, one for vertical-sump engines, one for horizontal-sump engines and one for angle valve K series 6 cylinder engines. Certain engine types may require an additional port to be installed in the sump. You may also opt for sump port relocation that places oil pick-ups in optimal locations extending and enhancing system performance in vertical or knife-edge flight.

These instructions will guide you through the installation of the Raven Inverted Oil System. Please take the time to read all instructions and carefully plan the installation before you begin. Review the diagrams to gain a complete understanding of the function of the system. Different engine configurations and mounting preferences may necessitate slight modifications to installation methods depicted in the diagrams. If you have any questions about the type of installation necessary for your particular engine, please contact a Raven technician before you begin.

Look over the main diagram (Fig 8) and note the location of all components and the hose routing, this will help you understand where everything is located and the approximate routing of the hoses.

How does it work?

Installation of the Raven Inverted Oil System results in the modifications shown in figure1 and 2. (4 Cylinder engines), and figure3 (6 Cylinder engines). Compare these diagrams to familiarize yourself with the modifications. During normal flight (see figure 4) the ball valve at the top of the Oil Separator (the round tank) is open, allowing blow-by gases from the engine's breather port to

be vented normally. The top ball valve in the Oil Valve (the round part with 3 ports) is closed and the bottom valve is open, allowing oil to flow from the pick-up tube in the bottom of the sump, through the valve and to the oil pump. When the aircraft is inverted (see figure 5) engine oil is now in the top of the crankcase and the pick-up tube in the sump is no longer in oil. The weighted ball valve in the Oil Separator closes preventing oil loss through the breather port while venting blow-by gases from the sump instead and out through the breather line. The top ball valve in the Oil Valve is now open and the bottom valve closed. Allowing oil to be picked up and redirected to the oil pump. Oil left in lines during the transition between normal and inverted flight is captured by the Oil Separator and is returned to the sump during normal flight.

Fig 6 shows an optional modification to use on the K series 540 engine with the stock sump, inquire for more information of this new kit offered by Raven Aircraft.

Please contact us if your sump does not match one of the above, we do have specific instructions for the stock Angle valve sump as well as **Superior**, **Titan** and other cold air sumps.

Installation Precautions

Carefully plan the location of components and routing of hoses before you begin actual installation. The following rules are critical to proper system performance:

- The Oil Separator must be mounted as high as possible. This ensures rapid emptying of the separator following transition to normal flight. It is also best to mount it as far off to the side as possible. Make sure to install the separator so that the larger 3/4" NPT fitting is up and the smaller 1/2" NPT is down.
- The bottom of the Oil Separator should be at least two inches above the top of the sump and the centerline of the Oil Separator should be at least ten inches from the sump centerline on the either side of the engine and ***MUST be*** **mounted on the** ***opposite side of the oil return fitting/port on the sump*****.** This prevents oil loss during some maneuvers such as knife-edge flight.
- For horizontal-screen sump engines, the Oil Valve must be located such that its center port is vertically located as close as possible with the sump screen access port, an inch or so up or down is ok. The valve can be positioned anywhere left or right on either side of the engine. It is best to mount the valve as far away from the engine as possible and as close as possible to the firewall edge, this allows the easiest routing of hoses. For vertical-screen sump engines, the Oil Valve must be aligned such that its center port is vertically located as close as possible with the bottom surface of the sump. You can rotate the new adjustable Raven oil valve so that the ports will line up to allow the easiest routing of the hoses.
- The oil line fitting in the bottom of the Oil Separator must be either straight or 45-degree to ensure rapid emptying of oil in the separator to the sump.
- Keep hose lengths to a minimum when possible, however hose routing should be smooth and sweeping. Avoid sharp bends which would collapse hose walls and restrict oil flow. Again it is best to have the valve located off to one side of the engines port to make installation of those hoses easier
- The hose from the bottom of the Oil Separator must extend in a continuous downward slope to the bottom of the sump. This ensures complete emptying of the separator.
- An appropriate breather fitting must be provided to permit connection of the breather hose. Six cylinder engines normally use 1-inch diameter hose while four cylinder engines use 3/4”, these can be reduced to 7/8” or 3/4” for 6 cylinder and 5/8” for 4 Cylinder engines if there is no way possible to run the larger lines. The engine most likely has a 5/8” fitting installed, to adapt the 3/4" ID hose it is best to make up a small sleeve out of rubber or plastic.

Caution: Use care when threading fittings into aluminum! Aluminum pipe threads are subject to damage from over-tightening! **ALWAYS** use thread sealing compound on the threads even for test fitting. Do ***not*** use Teflon tape but liquid Teflon is good to use and is preferred. Pipe threads will seal with only moderate force when using an appropriate thread compound. If installed fittings cannot be turned to the desired angle using only moderate force, remove the fitting and tap the threads slightly deeper to allow additional rotation. Take precautions to ensure that metal chips do not enter the engine or system components.

Proceed with the Installation

1. Remove drain plugs from the sump and drain all engine oil.
2. If your installation requires the installation of additional sump bosses, remove the sump. Locate boss positions as shown in figures 1 and 2. Bosses are normally attached by pre-heating the sump then Tig welding them into place, **Note** – ***Special welding procedures are required when installing bosses in place, these procedures must be followed to avoid possible cracking and failure of welds in cast aluminum and especially cast Magnesium sumps*.** Normally 4 Cylinder sumps are Aluminum and 6 Cylinder sumps are Magnesium, be sure to find out what material your sump is made from to make sure you get the correct weld boss kit for your application. Carefully shape the base of the boss to the sump to provide a snug fit prior to welding. Once welded, re-tap the threads. Clean, repaint and re-install using a new gasket and lock washers.
3. For horizontal-screen sump engines, install the Sump Plug and Sump Fittings as follows. (Refer to figure 7).
    a. Remove and discard sump screen access plug at rear of sump.
    b. Remove sump screen.
    c. Oil the O ring and insert the sump Plug through the sump screen access port (using a long AN3 bolt or a length of 10/32 threaded rod) and press firmly into position, make sure the plug is indeed correctly seated by giving it a light tug with bolt/threaded rod still in place, it should take some force to unseat it. If is pulls very easily out check it to make sure the O ring is in place and not damaged, if it is still loose when reinstalling check with us regarding possible solutions. When you are sure it is installed and seated correctly unthread the bolt/threaded rod and proceed with the rest of the install.
    d. Shorten the sump screen- If using the **Straight Fitting** start by removing 3/16" from one end, the screen should end up being approxx 4-5/16" long. **Note** - If using the **45 Degree Swivel Fitting** you will need to shorten the screen considerably more, approxx 5/8", the screen should end up being approxx 3-7/8" long. ***Note** – *As on option you could use a piece of 5/8" aluminum or steel tubing to determine the length and then cut your screen to that length. This would limit the possibility of cutting your actual screen incorrectly.*
    e. Now test fit the screen by placing the sump screen into the recess in the front of the Sump Fitting and insert the screen through the sump screen access port without the copper ring. The front of the sump screen will slide over the hub of the previously installed Sump Plug. Screw in the Sump Fitting finger-tight until the sump screen is firmly seated. ***** **Note** – *Due to variances in the threads of some sumps the fitting may be tight to thread in, if this is the case lubricate the threads well and carefully feel for the resistance of the screen. Upon final install take care to **not** overtighten the fitting.*
    f. Measure the gap between the front of the Sump Fitting flange and the face at the access port. This will indicate the amount that the screen needs to be shortened to reduce the gap to approximately 1/16 of an inch (the thickness of the copper ring). If the screen is shortened too much possible leakage will occur during inverted flight resulting in lower or no oil pressure.

g. Remove the sump screen and carefully shorten the screen by the amount determined.
h. Repeat steps e, f and g until the proper gap is attained. Now completely clean and prepare the screen and remove any burs or chips. **<u>*Note</u> – *Care must be taken to shorten the screen to ensure it is the correct length as the screen holds the sump plug in place. If it is cut too short the plug may leak and cause low or no oil pressure when inverted, in extreme cases shortening the screen too much can allow the plug to fall out and cause zero oil pressure when inverted. If the screen is left too long it will prevent the 45 deg swivel fitting from turning and may put excess pressure on the internal snap ring.***
i. Finally install the sump screen with the copper ring and Sump Fitting. Tighten the fitting firmly, care must be taken to ***not*** overtighten the fitting. If using the 45 degree fitting position the outlet to the desired angle then tighten the set screw**.*Note*** You **must** safety wire the outer part of the fitting to ensure that it will never thread itself out.

4. For Vertical-screen sump engines, install Sump Fittings as follows:

a. Remove and discard sump screen access plug in bottom of sump.
b. Remove and discard sump screen.
c. Verify that the internal O-ring is in place in the Sump Fitting. Apply a coat of engine oil to the O-ring.
d. Make sure that the internal oil pickup pipe is centered then place gasket over the Sump Fitting and install in sump screen access port.
e. Install elbow and set position to point towards the Oil Valve mount location.

5. Securely mount the Oil Valve in position on the engine mount or firewall. Verify again that the center port is properly aligned as previously discussed. **NOTE**: If you have one of the first or second generation valves please check with us regarding our valve exchange program!

6. If installing a used valve you **MUST** Check the valve as follows before installing it: Hold it vertically, seal your lips against the surface and simply blow pressure into the top port, there should be no leakage, turn over and repeat, next with the valve vertical again check to make sure that the spring is free to move, (you can use a small screwdriver or something similar to lift the spring), it should have a minimum of 1/8" free play, rotate and check again. Lastly with the valve vertical again, hold the ball in the top port lightly in the seated position, rotate valve and make sure the spring holds the 2 balls apart so that they ***cannot ever*** come together so both are seated at the same time, the spring MUST hold the balls apart, this is ***very*** important for proper operation. If unsure about any of this check with us at Raven Aircraft.

7. **Note** – There were 2 different diameter bore sizes and springs used in our valves, make sure to keep the correct spring with each valve if it is ever disassembled. If you are unsure please contact us for details.

8. Securely mount the Oil Separator is as high as possible and aligned as previously discussed.

9. Install remaining fittings. ***Note*** If using a **"T"** supply fitting with oil cap you must safely wire the cap in place, if you do not have a drilled cap contact us and we will supply you with one at no cost.

10. If installing a Vac Adapter make sure the 90 degree AN Fitting is installed first and install the housing so the fitting is at the bottom, test fit to obtain the best angle to adjust the fitting to as this area is tight.

11. **NON ACC VAC PLATE - Before installing this plate you must determine that this plate will work on your particular engine. *Please read 11 and 11B fully before proceding*.** If you are installing a Non-Accessory Plate you **MUST** *remove the gear* **AND** *the gear housing* if installed, this adapter must sit flat against the accessory case itself or no oil will reach the valve which will result in zero oil pressure. (This is **VERY** important because if you install the pickup with the gear and housing in place you will have zero oil pressure when inverted, in this case oil pressure will not return after transitioning back to upright due to the oil pumps vacuum force holding the lower ball in place, this vacuum will only release the ball after the engine stops and will still take some time to do so. If you remove the gear only and leave the housing in place you will have low oil pressure at all times.

    You may have to use long spacers when installing the pickup plate after removing the gear and housing, this is ok to do as you run the risk of breaking the studs to replace them with shorter ones.

    11B - Some engines use an internal gear instead of an external gear and housing, this adapter **will not work** with those engines unless the gear is removed ***and*** modifications are made. Please contact Raven Aircraft for further info. If the gear is left in place you will have zero oil pressure when inverted, secondly oil pressure will not come back when returning to upright flight due to the vacuum applied to the inverted valve by the engine oil pump. If the internal gear is to be removed the lubricating oil passage must be blocked or oil pressure will be low at all times. However the large opening has to remain open otherwise no oil will reach the plate. Please contact us for the correct procedures to remove the internal gear and block the oil passage.

    In order for this plate to work oil must be able to freely reach the housing with no gear blocking the passage.

    The vast majority of engines do have a separate gear housing and gear that are easily removed.

    If you have any questions or concerns please contact us before proceeding with the install.

    In **ALL** installations you must ensure you are able to see inside the engine case to be sure there will be no obstruction of oil flow.

12. Measure, cut, and install breather line hose using worm-drive hose clamps. Avoid sharp bends and kinks and observe hose markings to avoid helical twists. To prevent hose collapse on bends of less than a 4-inch radius, install a Breather Coil. 3/4" ID hose is recommended, however the engine most likely has a 5/8" fitting installed. To adapt the 3/4" ID hose it is best to make up a small sleeve out of rubber or plastic, just make sure it has a slit to allow it to compress, another method is to carefully heat up the hose and squeeze the end with the hose clamp.
13. Measure, cut and install hose for remaining oil lines. Remember to allow exactly 1 inch for each hose fitting if using 303 hose. To install Aeroquip fittings first thread the outer sleeve counter clockwise onto the hose, thread it far enough until it bottoms out then back off a quarter turn. Mark the hose with tape at the base of the sleeve, (this is used for reference to ensure the hose does not get pushed out when installing the internal part). Next clamp the sleeve into a vice and install a mandrel tool threaded into the remaining parts of the fitting. Use lots of oil in the hose and on the fitting at this point, next thread the inner part clockwise (You may need to push it slightly to start the process) into the outer sleeve until it almost bottoms out, (leave enough room so that the nut will rotate freely), check to make sure the hose has not been pushed out of the outer sleeve and remove the mandrel tool, now you are done!

14. **Note** – Ensure that the hoses are long enough to allow movement of the engine and that there is no force to stress the sump fittings, if not enough movement is present there is a possibility of cracking or breaking these fittings.

15. ***Inspect your work! Double-check hose bends for smoothness, check each fitting for tightness, and verify <u>all components</u> are securely mounted and hoses are tight!*** All hoses and fittings should be witness marked as well.

Initial Ground Check

1. Add oil to the correct level.
2. Before you start your engine it is best to prime the system by turning the engine with one spark plug from each cyl removed. <u>(Please refer to Lycoming Service Instruction No. 1241C.)</u> After priming replace the spark plugs and wires, now start your engine. Oil pressure should rise to normal readings after 10 to 12 seconds. There will be a variation in pressure reading from standard readings prior to installation of the Inverted Oil System. *(Refer to paragragh 4 below to correct this.)* If oil pressure fails to rise after 20 seconds, shut off the engine and begin *troubleshooting procedures.*
3. After running the engine for a short time inspect all fittings and hoses for leaks. If any leaks noted, take corrective action. Now run the engine for a longer period and check again. If all checks are completed and you are ***absolutely sure*** all fittings, hoses etc are installed correctly and there are no leaks proceed to the next step.
4. When engine is at normal operation temperature, check oil pressure reading again. It may be necessary to compensate for oil pressure reductions caused by the additional oil flow through the Inverted Oil System. The pressure can be adjusted by resetting the pressure relief valve. Adjust according to the engine manufacturer's recommended setting. This adjustment is done either by turning a screw or by adding shims depending upon engine model. If pressure is still low there are stronger springs available.

Initial Test Flight

The system checks on the ground also have verified the system as it would operate during level flight. To check the system in aerobatic flight, perform the following steps:

1. <u>Before flight pre-fill the top oil line from the Non Acc plate/Vac adapptor to the valve.</u> Fly the aircraft at a safe altitude and roll to inverted attitude, for safety reasons you **MUST** do this over an airport. There will be a momentary drop in oil pressure but should return to normal pressure within 2/3 seconds. If no return to normal pressure occurs within 8 -10 seconds, roll to normal flight **<u>immediately</u>**. **NEVER** let the pressure to continue to drop to the point that a constant speed prop will allow the engine to overspeed. Initial system operation may take several attempts, as it can be difficult to start oil flow in dry hoses and passages. Try a series of abrupt inverted high-g dives and climbs. If inverted oil pressure still fails to rise, land the aircraft and troubleshoot the system.

2. Note that due to the longer oil flow path during inverted flight, oil pressure may be 5 to 10 pounds less during inverted flight than during normal flight.
3. Land the aircraft and inspect all hoses and fittings for leaks.
4. If after rolling inverted then back to level flight you do not notice oil pressure attempt to re-seat the valve by pulling G's.

System Maintenance and Troubleshooting

With the proper operation of the Raven inverted Oil System, only very small losses from normal oil level will occur, due to certain combinations of aerobatic maneuvers that do not allow for the drainage of the oil separator during periods of normal flight. Abnormally large losses of oil could occur should the aircraft perform a lengthy series of certain maneuvers with little or no normal flight attitude to allow drainage of the oil separator. Avoid this by simply allowing for normal flight attitude during aerobatic flight. It is recommended to transition to inverted on a *regular basis* to promote oil flow and avoid any sludge buildup in the oil valve. If you plan on flying the aircraft regularly with no inverted flight it is a good idea to remove the valve from the oil circuit and re install later, be sure to clean the valve and check as per our instructions in paragraph 6 on page 4 before returning it to service.

If oil pressure is normal during normal flight, but low during inverted flight, remember that a 5 to 10 pound difference in pressure is normal due to the longer flow path the oil must take. However, other conditions may also exist such as:

1. Damaged or leaking valve seats in the Oil Valve or Oil Separator.
2. Faulty seal at Sump Plug allowing air to be drawn into the system. Check sump plug for tightness and proper seal with O-ring.
3. Accumulated sludge or foreign material in Oil Valve or Separator. Remove and clean.
4. Collapsed or kinked breather hose. Check for smooth curves.
5. Obstruction in hoses. Clean thoroughly. (In rare cases hoses have collapsed internally and must be replaced.)

Low oil pressure in normal flight may be attributable to one of the following:

1. Clogged sump screen. Clean thoroughly.
2. Obstruction or accumulated sludge from lack of use in Oil Valve. Clean thoroughly.
3. Defective oil plump or pressure gauge.
4. Need to adjust oil pressure as outlined above.
5. Obstruction in hoses. Clean thoroughly. (In rare cases hoses have collapsed internally and must be replaced.)

Maintenance. Make sure to read this section thoroughly.

Normal maintenance is simply checking hoses and fittings for deterioration and leaks at normal inspection intervals, however it is advised to occasionally clean the valve. **Note** - ***This is absolutely necessary if the aircraft is not flown often, has sat for an extended period of time, if the engine has been replaced, or if the aircraft is not transitioned to inverted use regularly.*** To do this simply remove and rinse thoroughly with solvent, make sure to use a mild solvent that will not attack the powdercoated finish and never use strong solvents such as lacquer thinner. After it is rinsed then blow it out to dry it with compressed air then check for proper operation as per the instructions above in paragraph 6 on page 4.

The separator should be cleaned occasionally as well, to do this remove it and rinse out with mild solvent, when done make sure the internal parts are moving, you can check the top ball visually for pitting as well. To check the seal fill it partially with solvent holding it upside down, (large port on the bottom) there should be little or no seepage.

Normally the valve will never need to be disassembled, however if you choose to do so care needs to be taken, in some instances you may need to heat the ends with a heat gun to soften the liquid Teflon before removing the plugs.

Note – If you do choose to disassemble the valve yourself you **must** use safety wire upon reassembly to ensure the threaded caps will never be able to completely come out. If your valve is undrilled you **must** drill it in 4 places to allow the ends to be safety wired. If you are unsure how to do this, we will perform this for you at no charge, contact us for details. You must also use liquid Teflon to seal the caps, before reassembling make absolutely sure ***all*** Teflon residue is removed, then make sure the caps are tightly torqued in place. (Contact us for more detailed instructions if needed)

When reassembling be very careful to ensure no sealant ends up inside the valve as this could prevent one or both balls from sealing properly. After re-assembling the valve you must check for proper operation before reinstalling. Do this by going through the following steps: Hold it vertical, seal your lips on the surface and simply blow pressure into the top port, there should be no leakage, turn the valve over and repeat. Next with the valve vertical again check to make sure that the spring is free to move, (you can use a small screwdriver or something similar to lift the spring), it should have a minimum of 1/8" free play, rotate and check again. Lastly with the valve vertical again, hold the ball in the top port lightly in the seated position, rotate valve and make sure the spring holds the 2 balls apart so that they can never come together and seat at the same time, the spring MUST hold the balls apart. This is ***very*** important for proper operation. If unsure about any of this check with us at Raven Aircraft.

Note There were 2 different diameter bore sizes and springs used in our valves, make sure to keep the correct spring with each valve if it is ever disassembled. If you are unsure please contact us for details.

If you have any questions or concerns please do not hesitate to contact us at (604) 576 9871 or email us at ravenair@uniserve.com.

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