Oil Pressure Diagnostics

Using Gage Readings to Diagnose Your Engine

By Roger Moment, Rocky Mountain Club

Low oil pressure gage readings indicate potential for the possibility of serious engine repairs, ranging from renewing the rocker shaft and bushes to replacement of bearings (and the usually associated regrind of the crankshaft and other major work).

Lower-than-expected pressure on a rebuilt engine, however, raises other questions, such as whether the crank and bearing sizes were indeed correctly matched, or the possibility of some other unknown gremlin from within. There is a way to use basic fluid physics and the gage readings to isolate the problem in either case, and perhaps avoid wasted time and expense from an unnecessary engine tear-down.

Fluids are incompressible, and in an engine lubrication

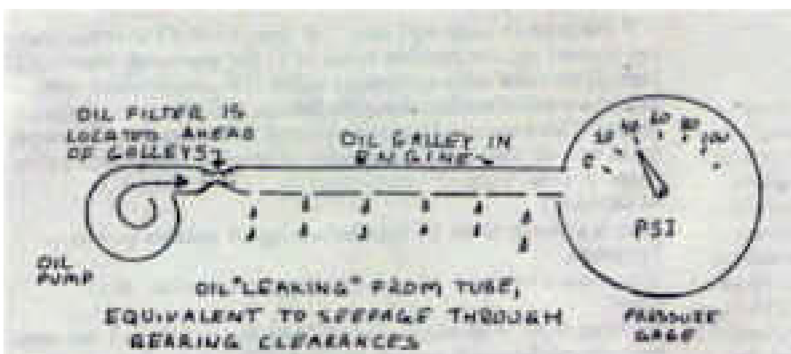
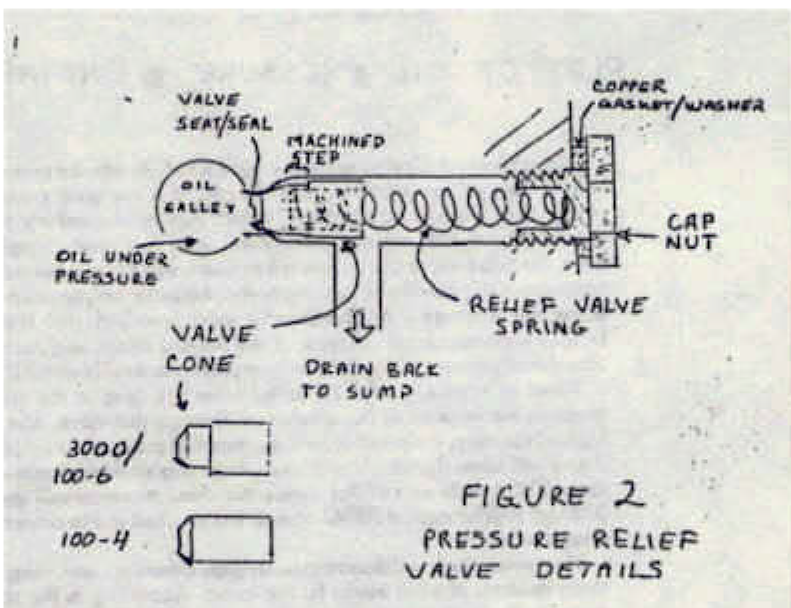


FIGURE 1

The pump sends oil into a long tube, which represents the passageways throughout the engine including the crank, oil filter, rocker shaft etc. The tube has a number of "leaks" in it which represent the bearing clearances which, because they are not zero, allow some seepage as the oil performs its lubricating function. As the pump forces oil into the tube, pressure is zero until the rate of flow in is greater than the leakage rate out. From that point on, the pressure will build up in proportion to the pump output. Note that as the pressure builds, the flow rate through the leaks still increases too. The thinner the oil, the faster it will flow through the leaks, so as temperature rises, the lower the steady state pressure will be, for a constant flow rate from the pump into the tube.

Output from the oil pump goes up the faster the pump runs, so flow into the pipe will increase with engine speed. The "leak" opening size will stay essentially constant with temperature, so the rate of oil flow from them will depend on viscosity (inversely), which goes down as temperature goes up. (While multi-viscosity oils reduce the amount of this decrease, never-the-less your oil gets thinner and flows faster through bearing clearances as the engine temperature rises.) Using this rather simple model, one would expect oil pressure to go up with engine RPM, and the oil pressure gage to react to engine speed accordingly.

Now to establish better control over engine oil pressure, a relief valve is incorporated (located just below the oil filter on the engine block) which opens the passageway to allow more oil to "leak" from our tube in case the pressure builds too high. This valve is simple in operation -- a spring-loaded cone presses into a hole drilled into the oilway. When the pressure gets to a pre-determined level, it overcomes the spring pressure and pushes the cone from its seat, allowing oil to leak out and drain back into the sump. The higher the oil pressure, the farther back the valve cone is pushed, and the more oil "leaks" out. A subtle aspect of this design on 3000 engines is shown in Figure 2.



The cone sits like a piston in a cylinder, and has a short section of reduced diameter machined on the outside, as shown. When the cone moves back, oil passes past the face and then by this step to drain back through the side hole into the sump. This means that there is some restriction around the valve cone which also will limit the oil flow, even after it passes through the valve seat, and this can affect the measured oil pressure, as we shall see. (This shows why it is important for the relief valve in 3000s to have this machined step on the cone, for without it there is less room for oil to pass and this will prevent the valve from doing its job properly resulting in very high pressures, particularly when the engine is cold. The 100-4 valve doesn’t have this relieved feature, but oil flow past the valve cone is accommodated by location of the drain-back bole.)

So with the system as described: 1) the oil pump, whose output goes up with engine RPM, 2) the passageways, with "leaks" where the oil will flow faster as temperature rises and 3) the relief valve, which is set to allow excess oil to escape from the system once the pressure reaches a set level, let us now see what the oil pressure should read under a variety of situations.

Figure 3 is a plot of oil pressure vs. engine RPM. At idle the pressure is low, because the pump output at low RPM is not great enough to overcome all the bearing clearance "leaks". As engine speed is increased the oil pressure will correspondingly rise until it is great enough to force the relief valve open. The oil pressure will remain essentially constant, rising very slightly as engine speed is increased, up to a point where the flow rate through the relief valve is so high that it cannot be fully accommodated(because of the limited clearances), at which time the oil pressure will again continue to rise noticeably with RPM.

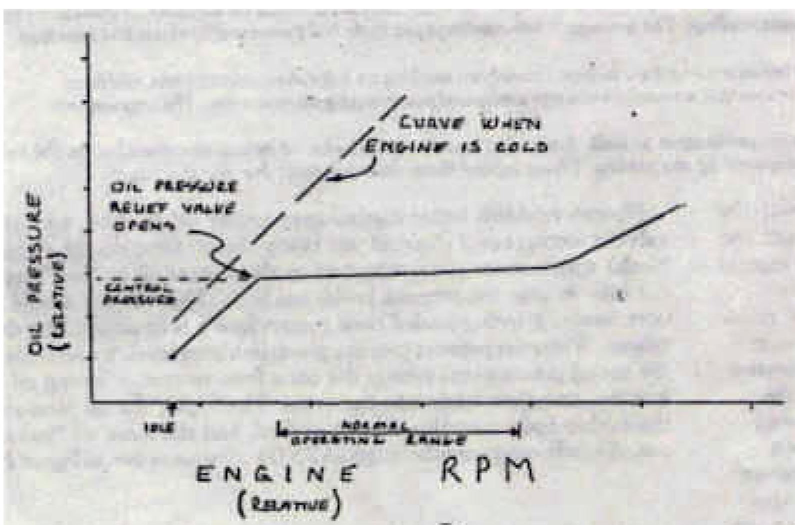


FIGURE 3

PLOT OF OIL PRESSURE vs ENGINE RPM

When an engine is cold, the relief valve will open at the preset pressure, but because of the clearances through this valve, and the high oil viscosity, it is possible for the controlled pressure to read higher than it will when the oil is hot. This explains why a cold engine may show 400 on idle and 70#at speed, but these pressures will drop to20#and 50#for similar RPMs after it has reached stable operating temperature.

Now we can look at different pressure gage behaviors, and interpret them in terms of what might be the cause. According to the shop manuals, the control oil pressure point for the 100-4 and 100.6 engine is 55-600 (with an idle pressure of 25-30#). The 3000 cars use a gear-type oil pump, which has a lower output flow, and the control pressure is also indicated lower at 50#(and 200 at idle).

If after the engine reaches operating temperature, the oil pressure rises and falls with engine RPM in the operating range of engine speeds then the control valve pressure is not being reached, and pressure is really being determined by flow from the pump working against losses through bearing clearances. In this case, one would expect to see pressures lower than 500, and excessive bearing clearances, a worn oil pump or a non-sealing relief valve are indicated. It is easiest to first check the relief valve to see that the correct parts are in place and the valve cone seating area is not damaged. Next check the rocker shaft for wear, and renew it and the rocker bushings if necessary, before doing the rest of the engine. You can also check engine bearing clearances by draining the sump, dropping the pan and use plastigage to check rod bearing clearances. The oil pump can be removed at this time and checked for clearances against the specifications listed In the shop manual.

There are a number of variations of this low oil pressure condition, depending on the RPM where the control valve appears to start operating (as indicated by essentially constant pressure as engine RPM is increased). An engine in good condition should reach steady oil pressure by 1500 RPM. In the worst case the pressure might increase with engine speed from near nothing at idle to 50# at 4000 RPM, and thus indicate only 30#or so at normal highway speeds. Intermediate degrees of wear would result in reaching the control pressure at an RPM somewhere between 2000 and 4000 RPM.

But what does it mean if the engine maintains a controlled oil pressure of less than 50# over a range of engine RPMs, but the pressure can be made to increase only if engine speed is raised to the higher end of the operating range(such as 4000RPM or more)? The controlled oil pressure over a range of RPM indicates that the relief valve is operating, and doing its job of limiting pressure. The oil pump is putting out more flow than is "leaking" through the bearing clearances. If the indicated pressure is less than the specification, then either the gage could be reading low OR the relief valve spring is weak, allowing the valve to open at too low of a pressure.

The increase at higher RPMs results from pump flow being too high for even the relief valve to accommodate without presenting some restriction, as discussed above. There are a number of specialists who can check the gage, but remember that to remove it will require draining the cooling system and carefully taking out the temperature gage sending unit and connecting tube. New replacement relief valve springs are available from a number of sources, and the stiffness can also be increased by inserting shims inside the cap- but that holds the relief valve/spring in place.

If the pressure reads well over 55# (say, 65-80#) after the engine has warmed up, the problem could be 1) the gage reads incorrectly high, 2) the relief valve spring is too stiff or3) the relief valve doesn't have the required machined step (in the case of 3000 engines, as noted above)~ This is not a problem to be ignored, for cold engine oil pressure could be well over 800, and capable of blowing out gaskets, galley plugs, or other seals.

SUMMARY

Here is a simple chart for troubleshooting oil pressure problems

Symptom; Idle pressure below 10 psi and running pressure under 20 psi.

Check; Sump oil level Also check that oil filter assembly has all the correct parts. People have unknowingly blocked off flow through the filter by incorrectly assembling it, and this cuts off oil flow resulting in very low pressure.

Symptom; Idle pressure below 15 psi and driving pressure varying from 20 to 40 psi with engine RPM in the range 2000-3500 RPM. Control pressure not reached.

Check; Oil pump clearances--see shop manual for specifications. Rocker shaft wear, engine bearings. Use of a heavier oil might help, but don't expect miracles.

Symptom; Idle pressure of 15 psi and control pressure reached around 2500 RPM or higher.

Check; Same as above, but wear should not be as great. Heavier oil might help.

Symptom; ldle pressure of 20 psi and control pressure reached at 1500 RPM, but value of this pressure is less than 50 psi.

Check; Oil control valve spring. You might also need to check that the control valve cone is not getting hung up on a burr thereby preventing it from sealing properly. You may need to also check that the valve seat edge is smooth.

With an understanding of the engine lubrication system, components, and basic principles of fluids and pressures, it is possible to use pressure gage readings (as a function of engine RPM and operating temperature) to diagnose probable sources of trouble and save unnecessary repair expense.

POSTSCRIPT NOTES from GEOFF HEALEY

While preparing this article I wrote to Geoff Healey and asked what experiences he might have recorded from the record runs at Bonneville Salt Flats. They were operating for long periods of time in an area known for high ambient temperatures in the summer. He had a number of comments to offer which would be of interest to Healey owners, which are presented here in slightly condensed form.

OILS

I don't think that a pressure around 40# should cause any problems. I think that the 20x/50 or SAE 40 would be the best oil for summer use in your area (Colorado). I suspect that if you filled your engine with Castrol XL of 50s vintage you would have an oil pressure around 50#. It is important to obtain a good oil flow at low temperature on starting, and for this reason oil viscosity is lower today. US manufacturers always used lower viscosity oils than the British." "This does not mean that British and US ratings are different. We use SAE ratings today, but in the early 50s I think you will find that Castrol made XL and Castrolite which did not carry an SAE rating. Also, branded oils available in Europe were generally "thinner" than the same spec. UK product. We always took supplies of the UK product with us when competing in Europe." "There was much more high speed operation in Europe than the USA. Clogged or restrictive filter elements were notorious for low oil pressure on the 3000. The Tecalamit felt elements gave less restriction than the Purolator paper elements, and oil pressure would be higher."

"The oils originally specified for temperatures between 32 and 90 degrees F were nominally SAE 30 and the oils were generally at the upper end of the SAE rating. For ambient temperatures above 90F the next heavier grade, i.e. SAE 40 was recommended. When multigrade oils became available, a warning that they were not suitable for worn engines was made. 20w/30 oil was at the lower end of the SAE 30 rating at 210F and often resulted in lower oil pressure. If a multigrade is preferred a 20w/50 is probably the most suitable for older engines.

"Most racing/rallying/record breaking was done using Castor base oils which approximate to SAE 40 grade. Occasionally a straight 50 grade or an extreme duty 40 grade diesel engine oil was used. These oils cannot be recommended for normal motoring. Oil temperatures in excess of 250F were often measured under racing conditions."

SMITHS GAGES

"The gages used on the Austin Healey were accurate to plus or minus 5%. On the face of the gage the maker's calibration points are marked below two or more pressure readings by two white dots. The needle should lie between these two points when subjected to a true pressure corresponding with the figures indicated. When gages require calibrating the dots should be used. 50 lbs./sq. in. actual should give a gage readings of 47.5 to 52.5."

BONNEVILLE RUNS

I found my note books with comments on Utah runs. Under the Stock car "Car tested 10 am-12am 11 Sept. 26 degrees C. . ending run 75-80 oil pressure high. Gage faulty. mean RPM 4000". This high reading was probably caused by very high pressure starting from cold straining gage. Under International car (100S) "oil temp=215C.. water 82C.air intake temp 30C". Actual oil pressure not recorded so it was not a problem. The oil was CASSTROL XL which was an oil having a viscosity at the top of the SAE 30 grade. Don't forget that these were new engines--the stock car had covered slightly over 1000 miles before starting the record runs."

OIL PRESSURE

"Only two cases of bearing failure were experienced with the 100-4 engines used for the development/endurance road testing/competition. Both failures occurred on starting a cold engine and were traced to filters that were heavily contaminated resulting in the excess pressure valve in the filter bypassing debris into the oilways.

"Oil pressure at idle with a hot engine was often around 5 lbs./sq. in. without any adverse effect on the engine. Many of today's engines have a low oil pressure light that comes on with pressures below 4 lbs./sq. in.

"Pressure should be around 50 lbs./sq. in. above 2000 RPM. Excessive pressure can cause bearing wear due to high oil flow through the bearings, as the oil has minute particles of contaminants that pass through the filter.

"The RPM at which the pressure relief valve starts operation can be used as a guide to engine wear. This assumes that the oil and filter are relatively new. If the oil has "thinned" with usage (cold running can result in unburnt fuel dilution of the crankcase oil) or the filter obstructed, the point of operation (RPM) would obviously be higher. I remember competing in the Tour de France Rally with the Nash Healey when we suffered from dropping oil pressure. We used to change the engine oil before every timed stage. This ensured satisfactory oil pressure during the period when the engine was used hard. After the stage the oil pressure would be much lower with zero pressure below 1000 RPM."

EPILOGUE

"Many engines ran thousands of miles with oil pressure well below the manufacturer's specification without any problems developing." "At Sebring it was found that on one of the fast bends that the needle would drop to zero and only return to normal after exiting the bend. This was due to oil in the sump surging away from the pump pickup. On stripping the 3000 engine after the race the bearings and crankshaft were found to be in excellent condition showing no evidence of oil starvation. Some of the most durab1e engines of old had very low pressure oil systems."